THE EVOLUTION OF INDUSTRIAL LAND USE WITHIN THE KNOXVILLE METROPOLITAN REGION: AN ANALYSIS USING AERIAL PHOTOGRAPHY AND HISTORICAL DATA FOR THE PURPOSE OF LAND USE MODELING

By

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A DISSERTATION PRESENTED TO THE GRADUATE COUNCIL OF
THE UNIVERSITY OF FLORIDA IN PARTIAL FULFILLMENT OF
THE REQUIREMENTS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY

UNIVERSITY OF FLORIDA
1975

DEDICATED TO:

Dr. (Jim) James C. Wilkinson

ACKNOWLEDGEMENTS

Of the many individuals who have contributed to this study, foremost is Dr. Clark I. Cross, Chairman of my Supervisory Committee. I am appreciative for his professional and personal assistance. His periodic encouragement has been most opportune. Dr. Gary Shannon has contributed both to this study and at other stages of my graduate career. I am grateful for his help. Dr. James R. Anderson has been a source of encouragement before and during my graduate tenure. To him I extend my appreciation. To Dr. David L. Niddrie I extend my appreciation for many engaging discussions. His intellectual vigor is a source of professional inspiration. The lectures of Dr. Clayton Curtis provided many ideas which are included in this study. To him my sincere appreciation is extended. Gratitude is also extended to Dr. Shannon McCune, Chairman of the Department of Geography and other members of the faculty for their assistance.

Finally, I wish to extend my appreciation to the following persons who contributed to the research effort: Mr. C. T. N. (Ted) Paludan at Marshall Space Flight Center; Dr. C. W. (Pete) Craven, Mr. Richard C. Durfee, and Dr. Michael M. McCarthy at Oak Ridge National Laboratory; and my family who patiently occupied the remainder of my home while I hibernated in my office.

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Abstract of Dissertation Presented to the Graduate Council
in Partial Fulfillment of the Requirements for the Degree of
Doctor of Philosophy

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March, 1975

Chairman: Dr. Clark I. Cross
Major Department: Geography

This research effort represents a portion of a much larger research goal, the identification of the determinants affecting land use change. This study focuses, however, upon only one aspect of this problem, the conversion of land to industrial use. The approach assumes that the determinants of the land use conversion process are found in the "market place," where land transactions among buyers and sellers occur. Only one side of the market transaction process is studied, however, namely that of the purchaser's desires (in this case, the industrial developer) in securing an ideal or suitable site. The problem was to identify the ideal qualities, quantities or attributes desired in an industrial site and to formulate a general algorithmic statement to identify potential industrial sites.

Research procedures involved the developing of a list of variables previously noted in the literature to be related to industrial site selection and streamlining the list to a set suitable for statistical testing. A sample of 157 industries which have located (or relocated) in the 16-county Knoxville metropolitan region since 1950 was selected for analysis. Using current and historical aerial photography data were collected on the location characteristics of each industrial site. These data were then subjected to factor analysis to determine the interrelations of variables, to minimize the list of variables needed to describe the industrial site-selection process, and to determine if the preconceived ideas concerning the factors affecting the process were valid. Seven factors accounting for 72 percent of the variance found in the original data were identified.

The 30 variables studied did not group as previously conceived but nevertheless the factors present a logical arrangement of variables. Four factors are almost singularly identified by accessibility characteristics. Reexamination of the accessibility factors indicates they could be combined, thereby reducing the number of indexes to two or three. The results suggest that a zoned or designated place for industry to locate, open space suitable for industrial development, and accessibility to the site are the three most important considerations in industrial site-selection decisions. Any algorithm intended to simulate industrial land use conversion should be constructed with these parameters as major components.

CHAPTER I

INTRODUCTION

Problem Background

Most urban and regional planners seek to answer the question, "What would happen if . . .?" The answer is not simply determined. "Even though equipped with the best information system, no . . . decision maker, however adept, can anticipate or visualize the many relationships which must be considered in a comprehensive, regional plan."[1] If, however, we could specify the correct development processes and represent them symbolically as a set of equations, the computer can approximate through simulation, years of regional growth in a matter of minutes. Before we can accurately simulate regional growth, the development processes must first be defined and understood, and by observing the limited success of previous land use modeling efforts we become acutely aware that we do not sufficiently understand them.[2]

---

[1] Charles R. Meyers, Jr., "New Tools for Regional Planning," AIA Journal, October, 1971, p. 1.

[2] Models should not be judged simply on a success-failure basis but rather in terms of the models' ability to answer questions about real world. In the past, some models have been more successful than others. For a review of previous modeling efforts one should consult: Ira S. Lowry, Seven Models of Urban Development: A Structural Comparison (Santa Monica, California: RAND Corporation, 1967); B. W. Mar and W. T. Newell, Assessment of Selected RANN Environmental Modeling Efforts. A report prepared for the Environmental Systems and Resources

We would expect land use change or growth to be stimulated or brought about by certain "triggering" events or mechanisms. Many early land use modeling efforts assumed the "triggering" mechanism to be brought about by the location of new industry. We now recognize that other stimulating mechanisms such as improvements in transportation or expanding demand for personal services also may prompt regional growth.[3] This research problem, however, is predicated upon the assumption that industry (specifically export industry) is the major stimulus for urban and regional growth and thus deserves initial consideration in any modeling effort.

Brown *et al*. recognized "the critical importance of industrial location. . .yet land-use modelers have devoted surprisingly little effort to analyzing the determinants of industrial location."[4] Only a few research efforts have made serious attempts to model the basic determinants of industrial location choices and "for the most part these attempts have been quite limited and crude."[5] *The focus of*

Division, National Science Foundation (Seattle: University of Washington, June, 1973); and O. Stradel and B. G. Hutchinson, *Notes for a Short Course on Practical Applications of Regional Development Models* (Waterloo, Ontario: University of Waterloo, The Transport Group, Department of Civil Engineering, November, 1971).

[3] Homer Hoyt was among the first urban economists to study the growth and development of urban land. His primary axiom was that "no city could grow by taking in its own wash." Homer Hoyt, *The Structure and Growth of Residential Neighborhoods in American Cities* (Washington, D. C.: U. S. Government Printing Office, 1939).

[4] James H. Brown and others, *Empirical Models of Urban Land Use: Suggestions on Research Objectives and Organizations*, Exploratory Report 6 (New York: Columbia University Press, 1972), p. 82.

[5] *Ibid*.

this study is on the conversion of land from prior uses to industrial use.

Statement of Problem

An initial requisite of any model purporting to replicate and predict industrial land use development is the identification of those land parcels having the greatest probability to change to industrial land use. It is necessary, therefore, to construct an algorithm which calculates the suitability of some land parcel for a specific industrial land use. The primary objective of this research effort is to develop a site-selection algorithm which identifies land parcels having the highest probability of attracting industrial land use. More specifically this research attempts to identify and measure the importance of the intrinsic site characteristics which appear to control the conversion of land to industrial use within the 16-county, Knoxville metropolitan region and to formulate a simulation algorithm to identify potential industrial sites.

Problem Operationalization

Intrinsic site characteristics refer to the qualities possessed by some land parcel which identify its suitability for a specific land use. In the case of industrial land use, examples of some of the attributes which should be examined are: proximity to rail service; access to nearby highways; site preparation costs; availability of city services; or whether the site is within a developed industrial park. The importance of these attributes may be measured and subsequently aggregated to form a combined measure or index.

The following is a list of indexes which are often identified as affecting industrial land use choices:

> Site Preparation Costs--The cost of converting rural or open land to manufacturing use. Matters which might be taken into account are foundation conditions, drainage conditions, slope of the land, and type of vegetation cover. This factor does not include the purchase price of the land.
>
> Market Price of Land--The per-acre cost of land to the manufacturer who wishes to build a new plant or expand his existing plant. This would include property taxes but not necessarily taxes on improvements to the property.
>
> Proximity to Suitable Labor Force--The number of suitable workers within easy access of the site.
>
> Transportation Accessibility--The ease with which people or materials can be moved from the plant site to roads, railroads, airports, or waterways. In this factor, the concern is with the linkage between the plant and major transportation facilities within the immediate area.
>
> Utilities--The kinds and quality of utilities available at the potential plant site. Some utilities which might be considered are water, sewer, and gas.
>
> Compatibility with Existing Land Uses--The compatibility of general manufacturing activity with other existing land uses adjacent to the potential site.
>
> Neighborhood or Community Attractiveness and Amenities--The condition and density of dwelling units and business establishments in the immediate area of the plant site, and proximity to hospitals, schools, parks, and churches.
>
> Industrial Park Space--The availability of suitable buildings or land in an industrial park. The appearance of the park and the quality of services produced are some of the considerations to be examined.

This list was compiled from both a review of literature and preliminary study. Each factor is a composite of several variables collectively identified as an index. Particular combinations of variables are not unique but simply represent logical groupings based upon the literature search. It is convenient for the purpose of this study to utilize this list as a beginning point to be refined after further study.

Each index posited is considered to reflect an information unit to be evaluted in the selection of industrial sites at the intra-urban scale. By combining these indices it is possible to develop an aggregate measure of the suitability of a site for industrial use. Before doing so, however, a weight should be attached to each index to reflect its relative importance in the location decision. A general mathematical form for the site selection algorithm follows:

$$LUS_{\ell} = \sum_{i=1}^{N} W_{i,\ell} \, I_{i,\ell} \; ;$$

where LUS = Attractiveness score for land use category ℓ (in this case ℓ = industrial land use),

N = Number of Indices,

$W_{i,\ell}$ = Index weight for the i^{th} index and the ℓ^{th} land use category, and

$I_{i,\ell}$ = i^{th} index for the ℓ^{th} land use category.[6]

Model Operation[7]

In modeling industrial land use development attractiveness scores are utilized in the following manner: Projected industry growth provided via a socioeconomic model is distributed initially to various subregions through a subregional allocation algorithm. Industrial expansion within the subregion is distributed to available land parcels on the basis of attractiveness scores calculated in the above manner. The availability of various land parcels is determined from knowledge of the probability that specific land parcels will be offered for consumption.[8]

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[6] Oak Ridge National Laboratory, Regional Environmental System Analysis, A Research Proposal Submitted to the National Science Foundation, Research Applied to National Needs (RANN) Feb. 1, 1973, p. 9.

[7] Land use models are constantly evolving and thus one can only speak of the framework of the model in a hypothetical manner. This may or may not become the structure of the model and represents only a tentative view as to the operating manner of the model.

The land use model as presently conceptualized is perhaps best characterized as a stochastic (Monte Carlo) model. Projected growth in land use will be awarded to various land parcels on the basis of the land use scores (LUS_{ℓ}). Basically, however, the model is heuristic in that as the land use conversion processes are better understood, analytic-deterministic procedures will be substituted for simulation-stochastic procedures.

Motivation for Study

It has been noted that "urban spatial organization is the outcome of a process which allocates activities to sites. In our society, the process is mainly one of transactions between owners of real estate and those who wish to rent or purchase space for homes and businesses."[9] The market process of "transactions between willing buyers and willing sellers determines the spatial organization of urban activities . . ." and thus should dictate the methodological structure of land use models.[10]

---

[8] The assumption that all land is potentially available is not a valid premise in that not all property owners are willing to sell property. Cadastral data and ownership characteristics necessary to develop a site-availability algorithm are not readily available and, therefore, very few land use models have included this consideration. The sociopolitical modeling team at Oak Ridge National Laboratory is currently studying the methods whereby local opinion and knowledge of owner characteristics may be utilized to identify land parcels which may be available for various land use activities. See: Osbin L. Ervin and Charles R. Meyers, Jr., The Utilization of Local Opinion on Land Use Simulation Modeling: A Delphi Approach (Oak Ridge, Tennessee: Oak Ridge National Laboratory, ORNL-NSF Environmental Program, 1973). Olaf Helmar, The Delphi Method for Systemizing Judgments about the Future (Los Angeles: University of California, April, 1966).

The market place however is not perfect. Individual land speculation, family or corporate property gifts, over-building by contractors, land use planners over-estimating demand, governments exercising property rights, the tendency for land uses to remain intact and the perpetuation of mistakes rather than corrections, all spoil the simple modeling of market transactions. However, after investigating numerous approaches toward modeling land use development, the market place appears to be the most viable way to approach the simulation of urban activities.[11] The site-selection algorithm seeks only to replicate the buyer's considerations in selecting an adequate industrial site. Seller considerations and market perturbations are not considered at this time.

The results of this research effort are intended to integrate with a "holistic" environmental model to be developed later. The motivation which stimulated this research problem, however, was the desire to understand the land use development process. After some preliminary analysis and review of previous research it became apparent that understanding and modeling land use change contained problems to occupy several dissertations. The decision was made, therefore, to focus upon one aspect of the land use evolutionary process, the development of industrial land use, in the hope that by expanding the understanding of this process, rigor could be added to the eventual development of a comprehensive land use model.

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[9] John P. Crecine, Computer Simulation in Urban Research (Santa Monica, California: The RAND Corporation, 1967), p. 2.

[10] Ira S. Lowry, Seven Models of Urban Development: A Structural Comparison (Santa Monica, California: The RAND Corporation, 1967), p. 5.

[11] *Ibid.*

Organization of Study

The organization of this study is: the present chapter attempts to introduce the reader to the research problem and to rationalize the need for the study. Chapter II discusses the literature from which a tentative list of site-selection variables was developed. In Chapter III, the test region is described and the research methodologies and procedures explained. Chapter IV presents the results of an empirical study conducted to identify and determine the relative importance of various location factors in the 16-county Knoxville region. Finally, Chapter V summarizes the conclusions derived from the empirical study and presents recommendations for the construction of a site-selection algorithm and recommendations for further research.

CHAPTER II

THEORETICAL AND EMPIRICAL STUDIES RELEVANT TO THE DEVELOPMENT OF INDUSTRIAL SITE-SELECTION ALGORITHM

The purpose of this chapter is to relate to this research effort ideas expressed within selected theoretical and empirical studies and to discuss the evolution of the indexes listed in the previous chapter. Discussion of some works may be abbreviated depending upon their relevance to industrial site-selection processes. Theoretical works involving classical location theory are discussed first, followed by a discussion of empirical studies of industrial location factors. The final sections discuss approaches utilized in other land use models and the development of a tentative list of variables.

Selected Theoretical Works

The location of industry in an intrametropolitan area is the result of a complex interaction of variables that can best be understood only through careful examination of historical events. Classical location theory, however, abstracts from reality by use of the principle ceteris paribus where one or two variables are permitted to vary while all other variables are held constant. Von Thünen's and Weber's studies represent early contributions to location theory and, thus, deserve first consideration in this study. More recent theoretical works follow.

Der Isolierte Staat[1]

Von Thünen's work dealt with a hypothetical agricultural land use system whereby transportation costs and economic rent were used to explain the location of specific types of agricultural production as they were concentrically displaced around a market center. In a similar manner, one might expect industrial, commercial, and residential land uses to arrange concentrically around an urban center (Figure 1). For a specific land use the utility (accessibility) derived from any location would decline with increasing distance from the CBD as in (a). This, of course, assumes that the CBD is the most accessible point within the urban area. The optimal price one would pay for utility or accessibility is illustrated in (b). Cost incurred in obtaining utility (Y) is represented by the area (XYZA) but the profit to be derived at utility (Y) is (ABCZ).[2] The profit is similar to the land rent of von Thünen's agricultural model. Thus, rent for various land uses can be expressed as a function of distance from the CBD as in (c). Based upon the comparative bid-rent capabilities of each land use, one would expect (RR_1) to represent the rent function for residential land use, (QQ_1) for wholesaling and industry land use, and (PP_1) for commercial and service activities. The intersections at Y and Z would form the boundaries between the various land uses.[3]

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[1] Johann Heinrich von Thünen, Der Isolierte Staat in Beziehung Auf Landwirtschaft Und Nationalökonomies (Berlin: Schumacher-Zarchin, 1875) in K. W. Kapp and L. L. Kapp, Eds., Readings in Economics (New York: Barnes and Noble, 1949).

[2] Michael E. Eliot Hurst, A Geography of Economic Behavior: An Introduction, Belmont, California: Duxbury Press, 1972, p. 231.

Commercial activities are the highest bidders for sites and usually occupy the most accessible places within the city. But commercial land uses are also found in the industrial and residential zones. Similarly, residential uses may also be found in other zones. For example, a four-story apartment building may yield several times more rent as a one-story commercial operation on the same site and thus may out-bid competitors for the property.[4]

Bid-rent functions are a very important real world phenomenon encountered in explaining industrial site selections. Industries seeking highly accessible sites upon which to build must compete against other bidders for those same sites. Consequently cost per unit acre, distance from CBD and proximity to transportation facilities were included as variables to be examined in this study.

Uber den Standort der Industrien[5]

Alfred Weber was among the first economists to pose a general theory of industrial plant location. The optimal location for an industrial plant was seen to be a formation of three factors:

---

[3] Ibid.

[4] Ronald Reed Boyce, The Bases of Economic Geography: An Essay on the Spatial Characteristics of Man's Economic Activities (Atlanta: Holt, Rinehart and Winston, Inc., 1974), p. 264.

[5] Alfred Weber, Uber den Standort der Industrien (Chicago: University of Chicago Press, 1928).

transportation costs, labor costs, and agglomerative forces. Weber theorized that the optimal location would be found:

1. where total transportation costs per unit of output were at a minimum or,
2. where transportation diseconomies were offset by savings through agglomeration factors or access to labor.

Of particular interest to this study are Weber's ideas concerning agglomerative factors and proximity to labor. In general, the ideas posited by Weber are of greater importance at the regional or sub-regional levels of industrial location than at the site level. Some of Weber's agglomerative factors, however, relate to industrial site characteristics and, thus, are considered in this analysis.

Weber's agglomeration factors are:

(1) The joint development of industries which promotes the attraction of auxiliary industries and increases the efficiency of large scale production and utilization of special technical equipment.

(2) The development and growth of specialized labor due to the greater opportunity for work in the area.

(3) The greater accessibility to raw material suppliers who can provide material regularly and on short notice.

(4) The reduction in overhead costs, such as gas, water, electricity, roads, and communications.[6]

---

[6] Robert G. Turner, "General Theories of Plant Location: A Survey," AIDC Journal, VI (October, 1971), pp. 25-26.

The Location of Economic Behavior[7]

The American economist, Edgar Hoover initially attempted to improve Weber's explanation of industrial location by including the consideration of such variables as the size of market area and institutional forces in his theoretical analysis. Yet Hoover, although critical of Weber's analysis, ultimately proceeded along the same lines to present his location theory primarily in terms of costs. Hoover, however, did expand Weber's agglomerative forces to include the importance of banks, utilities, fire and police protection, climate, property tax, and lower interest rates.[8]

Hoover also developed some generalizations in the locational habits of light industry versus heavy industry. Because of the necessity of "handling of large quantities of goods either coming in from elsewhere or being shipped out, heavier types of manufacturing, warehousing, and wholesaling prefer locations in transhipment zones along rail or waterways." "Manufactures, wholesalers and warehouses of less bulky goods need not be located on railroads or waterfronts at all, since they can be served by truck." They locate more in response to "the attractions of labor supply, cheap land, and nearness to local suppliers or customers. As a rule, they are found interspersed with commercial and inferior residence uses."[9]

---

[7] Edgar M. Hoover, The Location of Economic Behavior (New York: McGraw-Hill, 1949).

[8] Turner, op. cit., p. 27.

[9] Hoover, op. cit., pp. 128-129.

The site considerations of industries of the 1930's and 40's have changed in more recent times but several basic locational rules as expressed by Hoover and Weber remain intact. Accordingly, several variables such as neighborhood amenities, neighborhood compatibility, proximity to labor force, availability of utilities, adjacent land uses, and transportation accessibility have been included in this analysis.

Imperfect Competition and the Duopoly Debate

A number of location theorists believed pure competition was not a suitable theoretical structure for the study of plant locations, and sought to explain locations in terms of the competition between two firms attempting to capture the largest share of a market area.

Fetter[10] and Hotelling[11] were among the earliest to expound on duopoly location theory. They were followed by Lerner and Singer,[12] Smithies,[13] and Chamberlin[14] who expanded the original concept.

---

[10] Frank A. Fetter, "The Economic Law of Market Areas," Quarterly Journal of Economics, XXXVIII (May, 1924), pp. 520-529.

[11] Harold Hotelling, "Stability in Competition," Economic Journal, XXXIV (March, 1929), pp. 41-57.

[12] A. P. Lerner and H. W. Singer, "Some Notes on Duopoly and Spatial Competition," Journal of Political Economy, XLV (April, 1937), pp. 145-186.

[13] Arthur Smithies, "Optimal Location in Spatial Competition," The Journal of Political Economy, XLIX (June, 1941), pp. 423-439.

[14] E. H. Chamberlin, The Theory of Monopolistic Competition (Cambridge: Harvard University Press, 1936), pp. 194-196.

Devletoglou[15] recently commented on the economic irrationality of the approach and presented arguments against the theoretical base for such location activities. Important contributions, however, are still to be noted. Duopoly theory suggests consideration should be given to the repelling or attracting properties of industries which depend upon local markets.[16]

The Theories of David M. Smith[17] and Melvin L. Greenhut[18]

Smith's and Greenhut's contribution to the theory of industrial location incorporated the minimum costs approach of Weber with the maximum profit solutions of manufacturing location posited by August Lösch.[19] Smith calls this the maximin solution. The concept developed is illustrated in Figure 2.[20] In (a), the costs of production are permitted to vary over space (distance) and revenue obtained (demand) is kept constant. This is essentially the Weber solution. The basic concept of Lösch's model is shown in (b), where revenue is

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[15] Nicos E. Devletoglou, "A Dissenting View of Duopoly and Spatial Competition," Economica (May, 1965), pp. 140-160.

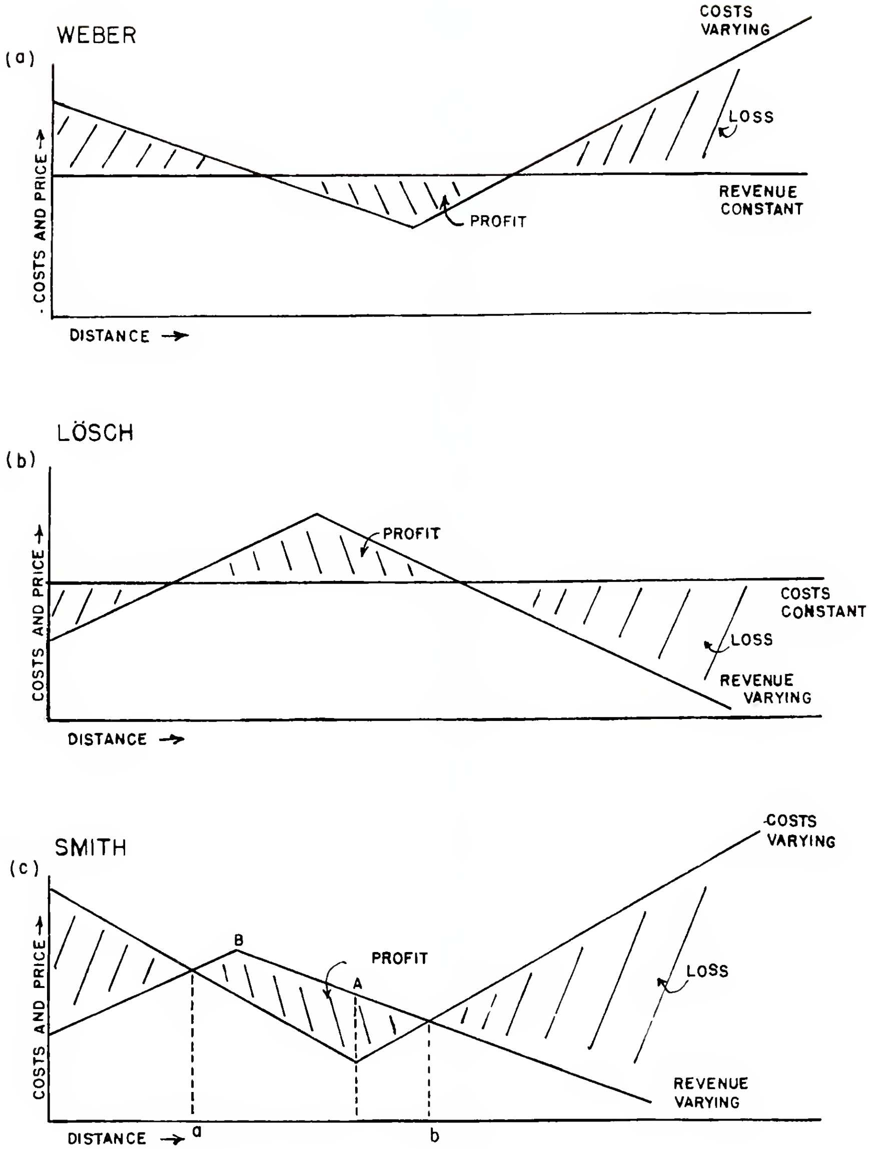
[16] Turner, op. cit., p. 31.

[17] David M. Smith, "A Theoretical Framework for Geographical Studies of Industrial Location," Economic Geography XLII (April, 1966), pp. 95-113.

[18] Melvin L. Greenhut, Plant Location in Theory and in Practice (Chapel Hill: University of North Carolina Press, 1956).

[19] William H. Weglom and Wolfgang F. Stalper (Translators), The Economics of Location, by August Lösch (New York: John Wiley and Sons, 1957).

[20] Smith, op. cit., p. 96.



SMITH'S MODEL WITH COMPARISONS (AFTER SMITH, p. 96)
Figure 2.

permitted to vary over space and costs are held constant. Finally, in (c) the combined solution suggested by Smith is offered with maximum profit occurring at A, where costs are lowest and profit is highest. Note that maximum revenue, however, is obtained at B.[21]

An interesting variation of Smith's model was the introduction of noneconomic factors, in particular, the concept of psychic income.[22] This innovation permitted social, psychological, or other personal factors to be entered into the model, hence relaxing the assumption of economic man. Such considerations according to Smith tend to divert the location of a plant from the ideal site to locations closer to the owner's home, a golf course, or perhaps a parochial school.

Smith suggests that stochastic procedures may ultimately have to be used to simulate industrial location decisions as personal factors cannot be accounted for by rigorous mathematical reasoning.[23] This research assumes that personal considerations may be accounted for by noting neighborhood amenities near the potential site. The importance of housing quality, proximity to churches, hospitals, schools, or parks and personal services availability in the immediate vicinity of the site are examined in this study.

Empirical Studies

The following empirical studies were significant resources in the development of a tentative list of site-selection variables. Two types of studies are presented: those studies directed primarily toward the industrial developer who seeks new industry for a community; and those studies which attempt to analyze industrial location considerations by way of a large sample of new industries and to categorize the locational considerations by industry types. Only one study is directed toward the development of a site-selection algorithm for a land use model.

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[21] Ibid., pp. 96-97.

[22] Ibid., p. 108.

[23] David M. Smith, Industrial Location: An Economic Geographical Analysis (New York: John Wiley and Sons, Inc., 1971), pp. 269-273.

The Studies of Allen Pred[24] and Richard Lonsdale[25]

Allen Pred has compiled a study of the history and present status of industrial location decisions within a metropolitan region. These patterns discussed pose interesting hypotheses for empirical analysis but the interest of this research is directed primarily to the site characteristics discussed by Pred. It should be noted that Pred's analysis focused upon a single metropolitan area whereas this study encompasses a region with a hierarchy of urban places.

In discussing location patterns, Pred identifies seven types:

1. Ubiquitous industries concentrated near the CBD - The market area of these industries is generally coincident with that of the metropolis or city. Food processing industries, specifically bakery goods, package foods, and fresh milk products, are some of the examples of these types of industries.

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[24] Allen R. Pred, "The Intrametropolitan Location of American Manufacturing," Annals of the Association of American Geographers, LIV (June, 1964), pp. 165-180.

[25] Richard E. Lonsdale, "Rural Labor as an Attraction for Industry," AIDC Journal, IV (October, 1969), pp. 11-17.

2. Centrally located "communication-economy" industries - Job-printing industries, newspaper printing, and advertising printing would be representative industries of this category.

3. Local market industries with local raw material sources - These industries show a high degree of randomness in their locational pattern but with some tendency toward CBD locations. Samples would be ice plants, concrete brick and block industries or industries whose raw materials are by-products of other large-scale industries such as the pulp and paper products industry.

4. Non-local market industries with high value products - Typically these industries provide a high value per unit weight product and are insensitive to transport considerations within the local region. The pattern is "at least superficially irrational." Computer and related industries and chemical industries are typical examples.

5. Noncentrally located "communication-economy" industries - The subset of industries includes those which are not necessarily pulled to any functional area of the city but rather tend to cluster together in any suitable area primarily because of the necessity to "keep abreast of the latest innovations or forthcoming contracts." Electronic, military equipment, and space age industries such as found in Huntsville, Alabama, or Houston, Texas, are examples.

6. Non-local market industries on the waterfront - Industries where primary raw materials are imported by water or whose finished product is often moved by water comprise this group. Petroleum refining, coffee roasting, and sugar refining are prominent among these types of industries.

7. Industries oriented toward national markets - These industries have extensive market areas and are influenced by high transportation costs on a bulky finished product. A large percentage of these industries have a tendency to locate on the side of the metropolis facing the most important market region. Pred identifies the Newark Lowland refining industry and the Detroit automobile industry as examples.[26]

Richard Lonsdale in a study of the locational habits of rural industry notes that those industries affected by transportation costs tend to locate in urban areas while those highly affected by labor costs gravitate to rural areas. In addition, Lonsdale notes rural firms tend to space themselves out in order to assure a labor supply.

Industries with tendencies toward rural locations are apparel, food products, textile, lumber and wood products, paper products, chemical, and electrical machinery - especially routine assembly. Low profit margins, keen competition, and high percentage[27] of production workers are some basic characteristics of these industries.

The patterns of industrial location detailed by Pred and Lonsdale are primarily identified with a spatial level slightly higher than the site-specific level which is the focus of this study. In relation to the development of the site-selection algorithm, variations in pattern are significant. It is obvious that separate weightings will have to be developed for each industry type, but this is not a primary objective of this study. It was anticipated that after developing a general site-selection algorithm additional research would permit the matching of various types of manufacturing to specific types of sites.

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[26] Pred, op. cit., pp. 175-178.

[27] Lonsdale, op. cit.

Historical Studies of Industrial Location Factors[28]

Numerous empirical studies exist of the factors associated with actual industrial location events. Although many of these studies were undertaken by academicians, the viewpoint is that of the industrial developer seeking to attract new industry or expand existing industry within the community.

Characteristically, investigations of this type are not concerned with a specified theoretical framework for approaching the problem but rather to learn the reasons for the location decision from persons acquainted with the location event. None of these studies were concerned with the construction of an algorithm to simulate the process of industrial land use development.

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[28] Discussion within this section is based mostly upon a review of the following articles: J. S. Bullington, "Utilization of State-Wide Site Evaluation Committee to Aide in the Location or Relocation of Plant Facilities," AIDC Journal, IV (October, 1969), pp. 27-42; James E. Chapman and William H. Wells, "Factors in Industrial Location in Atlanta, 1946-1955," Atlanta Economic Review, IX (September, 1959), pp. 3-8; Ronald E. Carrier and William R. Schriver, "Location Theory: An Empirical Model and Selected Findings," Land Economics, XLIC (November, 1968), pp. 450-460, and a more complete explanation of the study: Ronald E. Carrier and William R. Schriver, Plant Location Analysis: An Investigation of Plant Location in Tennessee (Memphis: Memphis State University, 1969); Melvin L. Greenhut and Marshall R. Colberg, Factors in the Location of Florida Industry (Tallahassee: The Florida State University, 1962); T. E. McMillan, "Why Manufacturers Change Plant Location versus Determinants of Plant Location," Land Economics, XLI (August, 1965), pp. 239-243; N. J. Stefaniak, Industrial Location within the Urban Area: A Case Study of Locational Characteristics of 950 Manufacturing Plants in Milwaukee County (Milwaukee: Wisconsin Commerce Reports, 1962); Charles M. Tiebout, "Location Theory, Empirical Evidence and Economic Evolution," Regional Science Association, Papers, III (1957), pp. 74-86; U. S. Department of Commerce, Industrial Location Determinants, 1971-1975 (Washington, D. C.: U. S. Department of Commerce, Economic Development Administration, February, 1973); and D. C. Williams and Donnie L. Daniel, "Industrial Sites for Small Communities," AIDC Journal, VI (April, 1971), pp. 33-39.

Greenhut and Colberg[29] analyzed factors influencing the decision of 400 manufacturers locating in the State of Florida between 1956 and 1957. Location considerations were divided into three groups: demand (market) considerations, costs (assembly) considerations, and personal (psychic) considerations. Access to markets and potential markets (Table 1) rated the highest among the location factors with the remaining factors surprisingly low. The study, however, was slanted toward measuring regional and subregional factors and thus was of limited value to this study.

The extensive study undertaken by Carrier and Schriver[30] of plant locations in Tennessee between 1955 and 1965 was conducted within the framework of existing location theory and, in part, did focus upon site-location factors. Many of the variables included in this analysis are based upon the conclusions reached in this study.

Carrier and Schriver identified six classes of location factors believed capable of affecting plant locations: (1) personal factors, (2) procurement-cost factors, (3) processing-cost factors, (4) distribution-cost factors, (5) location demand factors (including locational interdependency considerations), and (6) certainty factors.[31] (This

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[29] Greenhut and Colberg, *op. cit.*

[30] Carrier and Schriver, *op. cit.*

[31] Carrier and Schriver, *op. cit.*, p. 451.

Location Factors	Percentage of 400 Plant Listing as Primary Factor
Access to markets	51.9
Anticipation of market growth	12.8
Good labor relations	1.7
Lower wages	2.6
Ease of attracting out-of-state personnel, including research	4.7
Low freight cost on obtaining raw materials and components	7.7
Low cost on freight on shipping final product	10.7
Climate as it affects operations	1.8
Community facilities (education, police, medical, etc.)	2.9
All other factors	3.2

FACTORS MOST INFLUENTIAL IN THE LOCATION DECISIONS OF FLORIDA INDUSTRIES, 1956-1957

TABLE 1

class was identified after the interviews.) Certainty factors were defined as the confidence that the "prevailing and forecasted data used to identify the site offering maximum profits would persist into the future."[32]

Persons involved in the selection of sites for 307 manufacturing plants were interviewed. Each respondent was asked to select six factors from those listed in Table 2 and to distribute 100 points among these six in order to indicate the relative importance each factor contributed to the total plant location decision.

Of the 36 factors listed in Table 2, low cost and availability of labor was mentioned most frequently as the primary factor affecting the location decision (Table 3). Personal considerations without economic advantages received the highest average number of points, followed by low cost and availability of labor (Table 4).

On the basis of the interviews the authors grouped industries according to the six factors previously listed:

(1) Personal Factors - Miscellaneous manufacturing, furniture and fixtures, and food and kindred products were highly sensitive to personal factors with most of those firms being "home-grown."

(2) Procurement-Cost Factors - Industries which need large volumes of low-unit-value or perishable raw materials were characteristically affected by this group of factors. Food and kindred products, stone, clay and glass products, and lumber and wood products industries indicated greater sensitivity to these factors.

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[32] _Ibid._

1. Personal Factors;
    - Personal with economic advantages
    - Personal without economic advantages
2. Procurement-Cost Factors:
    - Better service from seller of raw materials and components
    - Low cost on raw materials or components
    - Availability of low cost raw materials
3. Processing-Cost Factors:
    - Low cost and availability of labor
    - Low cost of fuel
    - Low cost of electric power
    - Low cost of financing project through Area Redevelopment Administration
    - Climate
    - Favorable labor-management relations
    - Low cost of satisfactory type of water
    - Adequate waste disposal
    - Low cost of building and land
    - Low cost of financing plant through revenue or general obligation bonds
    - Favorable community and state tax structure
    - Community concessions
    - Available existing plant
    - Available existing building
    - Particular characteristics of building site
4. Distribution-Cost Factors:
    - Low freight cost, finished product
5. Location-Demand Factors:
    - Greater demand in the area
    - Greater demand potential in the area
6. Certainty Factors:
    - Nearness to metropolitan city
    - Community facilities
    - Community planning and zoning laws
    - Cultural qualities of the town
    - Community leaders' cooperation
    - Size of city
    - Data provided by Chamber of Commerce, community, etc.
    - Information provided by local manufacturers
    - Recreation, a good place to live, etc.
    - Nearness to corporate headquarters
    - Local supporting services
    - State administration neutral in labor-management relations
    - Progress in racial adjustment
    - Data provided by the state industrial development agency

LIST OF POSSIBLE FACTORS INFLUENCING INDUSTRY LOCATION AS UTILIZED IN THE CARRIER AND SCHRIVER SURVEY[33]

TABLE 2

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[33] *Ibid.*, p. 453.

Factor	Percent of Firms	Rank
Low cost and availability of labor	65.6	1
Low cost of electric power	36.0	2
Favorable labor management relations	35.7	3
Community leaders' cooperation	32.2	4
Low cost of building and land	19.8	5
Low freight cost, finished product	17.9	6
Available existing plant	17.5	7
Favorable community and state tax structure	17.2	8
Low cost of financing plant through revenue or general obligation bonds	16.9	9
Available existing building	16.6	10

TEN FACTORS MOST FREQUENTLY MENTIONED BY TENNESSEE FIRMS AS AFFECTING THE LOCATION DECISION

TABLE 3

Factor	Percent of Firms	Rank
Personal without economic advantages	49.2	1
Low cost and availability of labor	38.0	2
Available existing plant	35.9	3
Personal with economic advantages	32.9	4
Availability of low cost raw materials	31.9	5
Greater demand in area	30.2	6
Greater demand potential in area	29.8	7
Low cost of financing project through area Redevelopment Administration	29.6	8
Available existing building	27.6	9
Nearness to corporate headquarters	26.0	10

TEN LOCATION FACTORS WITH HIGHEST MEAN NUMBER
POINTS ASSIGNED BY TENNESSEE FIRMS INTERVIEWED

TABLE 4

(3) Processing-Cost Factors - These factors are associated with in-plant costs in assembling or processing the finished product, e.g., labor, energy, external services, capital, land costs, etc. Electrical machinery, apparel and related products, and textile mill products industries were affected by these factors.

(4) Distribution-Cost Factors - These factors reflect the costs incurred in shipping the finished products to the buyer. Among the most sensitive to these factors were food and kindred products, miscellaneous manufacturing, and paper and allied products industries.

(5) Location-Demand Factors - Industries affected by these factors are highly sensitive to market-demand in terms of proximity. Included in this category are paper and allied products, printing and publishing, and primary metal industries.

(6) Certainty Factors - The validity of existing and forecasted data is considered to be highly important by industries affected by these considerations. In other words, these industries want to know the future stability of costs in production and the probable continuance of existing markets. Printing and publishing, leather and leather products, and transportation industries were highly sensitive to these factors.

It is obvious that the scope of the Carrier and Schriver study is much broader than the objectives of this study. Its utility is limited for this research purpose. The factors considered by Carrier and Schriver span several spatial levels of locational decisions. The result is that factors which may be very important at the site-selection level are weighted low in comparison to the total list of factors. Also, the disproportionate number of factors offered for consideration under the six categories tends to skew the weightings. Finally, the lack of a very large sample in specific SIC categories tends to decrease the validity of the results of the weightings and, therefore, the conclusions reached regarding the typical locational patterns of specific industries.

Bullington[34] offers a scheme to locate potential industrial sites on a state-wide basis by suggesting the scoring of location factors on an ordinal scale and aggregating them into an index to determine the site potential for specific industries. Local and state governments could then match the qualities of the industrial sites available in the community to specific industries. The factors which Bullington suggests are listed in Table 5.

The U. S. Department of Commerce recently published the partially aggregated results of an extensive 5-digit industrial location survey conducted by mail throughout the U.S.[35] The purpose of the survey was "to assist the nation's underdeveloped and declining areas in the development of their economic resources and potentials."[36] Only manufacturing industries demonstrating "reasonable" growth between 1958 and 1967 were selected for inclusion in the survey. Survey forms were mailed to a total of 2,950 companies in 254 different

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[34] J. S. Bullington, "Utilization of a State-Wide Site Evaluation Committee to Aide in the Location or Relocation of Plant Facilities," AIDC Journal, IV (October, 1969), pp. 27-42.

[35] U. S. Department of Commerce, Industrial Location Determinants, 1971-1975 (Washington, D. C.: U. S. Department of Commerce, Economic Development Administration, February, 1973).

[36] Ibid, p. 1.

Site Characteristics

a. Size of Parcel
b. Shape of Parcel
c. Topography
d. Drainage
e. Flood Record
f. Condition and Appearance
g. Underground Water
h. Soil Bearing Capacity

Acceptability

(This referred to the potential friction or good-will prompted by the location of industry)

Accessibility

a. Highway
b. Secondary Roads
c. Rail
d. City Water
e. City Sewer
f. Limitations of Site

Community Factors

a. Commercial Air Service
b. Water Transport
c. Location in State
d. Mileage Rate
e. Airport Facilities
f. Comprehensive Planning and Zoning
g. Retail Accommodations
h. College
i. Community Appearance
    a. retail
    b. residential
j. Highways
k. Presentation of Facts by Community
l. Sanitary Sewer and Water Treatment and Facilities

LOCATION FACTORS SUGGESTED BY BULLINGTON

TABLE 5

SIC categories. One form, Survey of Industrial Location Determinants, was to be completed by all companies to identify the locational and operating characteristics of existing plants.

Only the results of the Survey of Industrial Location Determinants have been published to date and its usefulness for this study is limited because of the highly disaggregated form of the data. Hopefully, these data have been digitized by now and can be utilized for future analysis purposes.

The attributes measured or assessed in the survey are only slightly coincident with those sought in this analysis. Also the survey spans several spatial levels of locational decisions. Nevertheless, some of the variables utilized in the survey were included in this analysis.

Land Use Modeling Studies

Site-selection algorithms are certainly not novel to land use modeling methodologies. Numerous modeling efforts have utilized various allocation systems to distribute projected change in land use. Most of these approaches have been different from this approach in framework and in terms of the spatial scale of allocation. Previous land-use models usually operate at the census tract or county level simply because data (e.g., census materials) to calibrate the models are more readily available at those levels. The following studies, however, have approached the allocation problem similar to this study and consequently are briefly discussed below.

Among the first land-use models to utilize a site-selection algorithm to distribute projected land use change was one developed at the University of North Carolina by Donelly, Chapin, and Weiss.[37] The primary purpose of the model was to simulate the growth and spatial spread of residential land use. Historical data (1948-1960) were utilized to calculate an attractiveness probability to simulate the conversion of rural land to urban residential use. Changes were recorded by means of 1000-foot cells composed of nine 2.5-acre land development units.

The model operated in the following manner:

1. All land within the city unsuitable for development is eliminated from consideration at the beginning and the supply of land remaining is identified as available for residential use.
2. For each 1000 foot cell, a measure of relative value is established, i.e., land value, as a measure of its attractiveness for residential development.
3. The effect that "priming" (expansion of municipal services, commercial services, and industrial development) decisions will have on modifying the value of the property is then calculated for each cell. These are assumed to be exogenously given but in this case the exact amount is known from historical data from 1948 to 1960.
4. Land parcels are then "reassessed" to obtain a new attractiveness score.

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[37] Thomas G. Donnelly, F. Stuart Chapin, and Shirley F. Weiss, A Probabilistic Model for Residential Growth (Chapel Hill: University of North Carolina, Institute for Research in Social Science, 1964).

5. Density constraints (numbers of units per acre/year) are then introduced.

6. Finally, the known growth of residential households between 1948 and 1960 is allocated on a probability basis.[38]

The drawbacks to the model are: (1) the need to have historical data in order to develop the transition probabilities; (2) the disregard of the effect of changes in industrial location and employment; and (3) the vast amount of programming needed to load and run the model for a small region such as a single city. The concepts generated by this study, however, have become basic to many other modeling efforts and were equally important in this study.

The Pittsburgh industrial location model, INIMP[39] (Industrial Impact Model), is similar to the hypothetical design of this modeling approach; the major difference is that growth is distributed to census tracts and consequently the variables are more aggregated than those being considered in this study.

Four variables (attributes of census tracts) and one constraint were adopted as being sufficiently discriminatory to determine site locations. These are: weighted mean unit-assessed value of land; weighted mean unit-assessed value of buildings; weighted mean structural density, and amount of industrial clustering. These measures were determined by census tract. The constraint can either be imposed artificially as in the case of zoning controls or non-existence of services; or directly imposed by the model operator. On the basis of the aggregated scores of the above indexes, the model distributes a portion of projected city-wide employment changes among existing facilities and, upon reaching certain critical values of saturation, switches to a separate routine to distribute new facilities to census tracts having the highest scores for the remainder of the projected industrial employment growth. The distribution to various census tracts is accomplished by way of the maximum score. However, in the event of a tie, the allocation algorithm switches to a Monte Carlo routine. Similar but more elegant models of this type are being developed at Harvard[40] and the University of British Columbia.[41]

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[38] Ibid, p. 11.

[39] Steven H. Putman, "Intraurban Industrial Location Model Design and Implementations," Regional Science Association, Papers, IXX (1966), pp. 199-214.

A Tentative List of Variables

Each theoretical study reviewed approached the problem of explaining industrial location in terms of three components: demand, cost, and personal factors. Carrier and Schriver subdivided the process into six components: personal factors, procurement-cost factors, processing-cost factors, distribution-cost factors, location-demand factors, and certainty factors. Only processing costs, procurement costs, distributing costs, personal costs, and certainty factors have any direct relationship to site location considerations. Certainty factors may be considered a variation of location-demand costs. At the site level, procurement costs and distribution costs are sensitive to the variable, accessibility. Considerations of freight rates, transport modes, proximity to raw materials, supplies, etc. are more related to locational considerations at the subregional level.

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[40] Carl Steintz and Peter Rogers. A System Analysis Model of Urbanization and Change: An Experiment in Interdisciplinary Education (Cambridge: M.I.T. Press, 1971).

[41] M. A. Goldberg, Quantitative Approaches to Land Management (Vancouver, B. C.: University of British Columbia, The Resource Science Center, 1970).

In an effort to arrive at a tentative set of variables to be utilized in this analysis, a list of variables mentioned in the industrial survey literature as being related to the site selection decision was compiled. This list is found in Table 6.

A number of variables may be eliminated as not related to the site-selection process while others can be combined with other variables. After considerable study the following list of variables was developed to be used in a survey of the site conditions of past industrial location events. Selection was based upon the relevance of the variable to industrial site-selection and the ability to obtain measures of the variable. The variables are listed below:

I. Site Preparation Cost

   a. Slope of land
   b. Drainage
   c. Clearing-Cover conditions

II. Market Price of Land

   a. Distance to center of town
   b. Distance to nearest major thoroughfare
   c. Density of urban use in immediate vicinity
   d. Overall rating of price of land from 1 to 10

III. Proximity to Work Force

   a. Proportion of nearest city within 2-1/2 miles
   b. Population of nearest community

1. Industrial Park Space
2. Industrial Park Quality
3. Industry Nearby
4. Zoning and Building Restrictions
5. Pollution Regulations
6. Land Costs
7. Site Preparation Costs
8. Topography
9. Drainage
10. Soil Conditions
11. Place to Dump Effluent
12. Processing Water
13. Utilities
14. Municipal Water
15. Sewage
16. Natural Gas Service
17. Proximity to Local Markets
18. Proximity to Local Raw Materials
19. Proximity to Supporting Industry
20. Water Transport
21. Railroad Transport
22. Highway Transport
23. Commercial Airport
24. Distance to CBD
25. Community Transportation
26. Community Parking
27. Neighborhood Services (Restaurants, Hospitals, Parks, Gas Stations, etc.)
28. Nearby Housing
29. Nearby Labor
30. Community Cooperation
31. Community Stability
32. Community Wealth
33. Community Taxes
34. Community Progressiveness
35. Community Attractiveness
36. Community Labor Climate
37. Community University
38. Nearby Government and Institutional Facilities
39. Community Wage Rates
40. Space for Expansion

TENTATIVE LIST OF VARIABLES

TABLE 6

IV. Transportation Accessibility

a. Distance to major highway
b. Distance to secondary road
c. Distance to rail
d. Distance to airport
e. Waterway service
f. Distance to nearest Interstate interchange
g. Overall quality of accessibility from 1 to 10

V. Utilities

a. Water available
b. Gas available
c. Sewerage available

VI. Compatibility with Existing Land Uses

a. Did community have zoning at time of location?
b. Was site zoned for industry?
c. Was zone changed to accept industry?
d. Was industry already in immediate area?
e. Overall rating of contiguous land use compatibility

VII. Neighborhood or Community Attractiveness and Amenities

a. Condition of neighborhood
b. Density of land use in immediate vicinity
c. Nearby community services

VIII. Industrial Park Space

a. Was the site in an industrial park?
b. Overall rating of the quality of park?

Additional Data Collected

a. Proximity of site to Knoxville
b. Amount of other industry located nearby at time of event
c. Was building already there?

This list may omit variables which should be considered and, therefore, should not be considered exhaustive. However, it is anticipated that in measuring the importance of each variable some may be eliminated thus simplifying the site-selection algorithm. The next chapter explains the methodology and research procedures used to test the importance of each variable.

CHAPTER III

DESCRIPTION OF THE STUDY AREA AND ANALYSIS PROCEDURES

This chapter describes the research methodologies utilized in this study. The first part of the chapter describes the eastern Tennessee study region, the second part the data collection procedures, and the final part the analysis procedures.

The Study Region

The study region encompasses 16 counties surrounding and including Knoxville, Tennessee, (Figure 3) and represents an administrative entity called the East Tennessee Development District (ETDD). The region spans 6,500 square miles and contains a population of approximately 750,000 people. Its selection for this study was based upon the availability of data in the Oak Ridge National Laboratory (ORNL) Data Base.[1] ORNL selected the region on the basis of "the diversity of the region, the availability of data, the presence of cooperative and interested user groups, close proximity, etc."[2]

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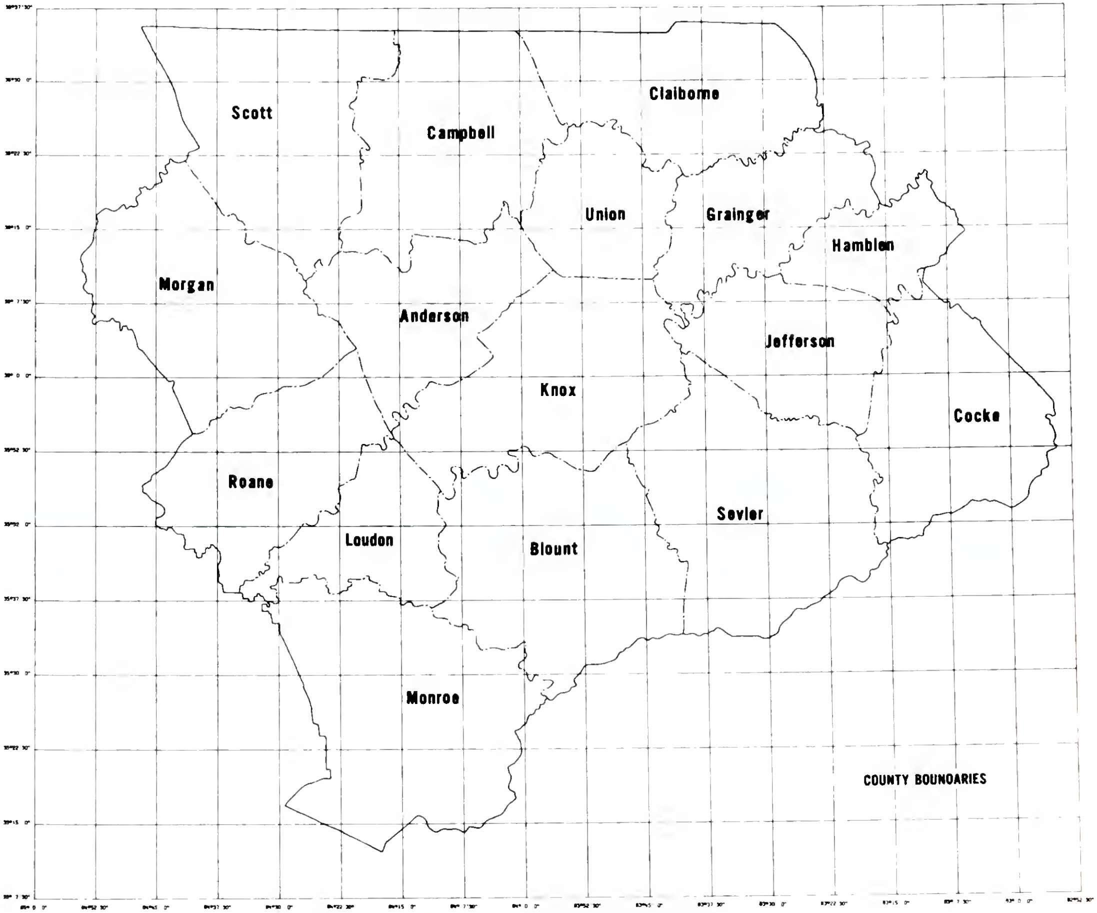
[1] Oak Ridge National Laboratory is currently developing a "holistic" environmental model for the ETDD region. This research was supported by this program. ORNL-NSF Environmental Program, Regional Environmental Systems Analysis (A Research Proposal Submitted to the National Science Foundation, February, 1972).

[2] *Ibid*, p. 3.



EAST TENNESSEE DEVELOPMENT DISTRICT
Figure 3.

The ETDD region is centered in the southern portion of the Ridge and Valley Province (the "Great Valley"), bordered to the northwest by the Cumberland Plateau and Mountains, and to the southeast by the Great Smoky Mountain complex (Figure 4). Both the Smokies and the Cumberlands are characterized by steep slopes and forest cover, with the Cumberlands distinguished by strip mining scars.

The area is drained by the Tennessee River system, the natural flow of which has been vastly altered by the Tennessee Valley Authority (TVA). By harnessing the power of the river system to produce low cost electrical power and developing a navigable channel to Knoxville, TVA has become the major development agency within the study region. As a result much of the industrial development in the region has been structured by TVA activities.

The largest urban center in the region is Knoxville which serves as the major economic and transportation focus for the region. Surrounding Knoxville are Oak Ridge, Maryville-Alcoa, and more distant Morristown, each with between 20 to 35,000 in population. These cities perform subregional functions. Remaining urban centers are small in population and are mostly located within the confines of the plateau and the Blue Ridge (Figure 5).

Industry within the Region

This analysis has concentrated upon secondary manufacturing (SIC 20 through 39) and excluded extraction industry (SIC 10 through 19).[3] The location determinants of extraction (or primary) industry are

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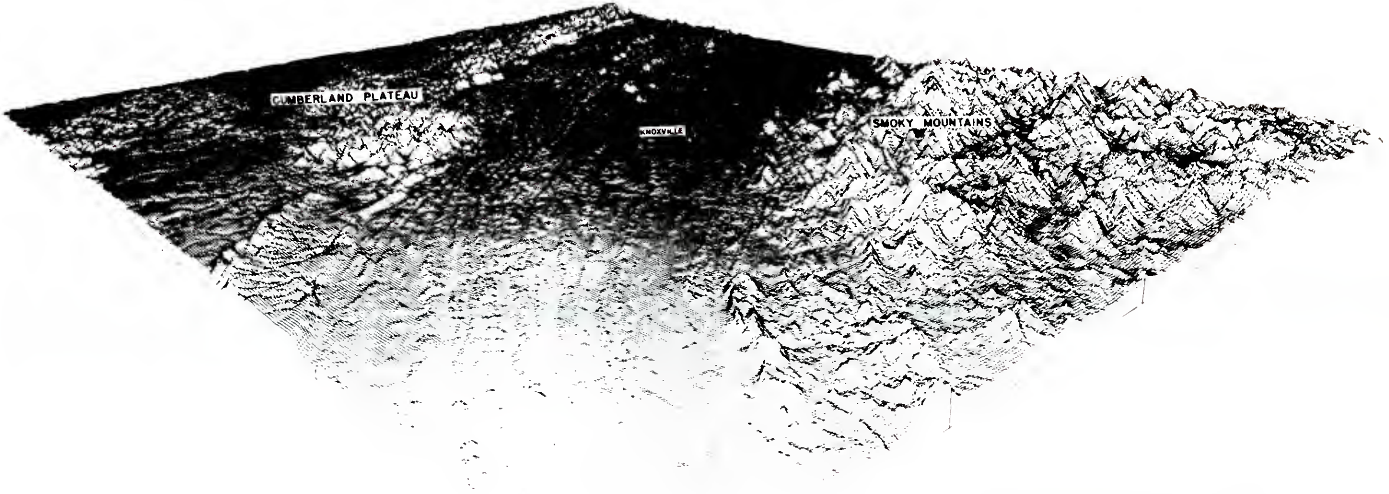
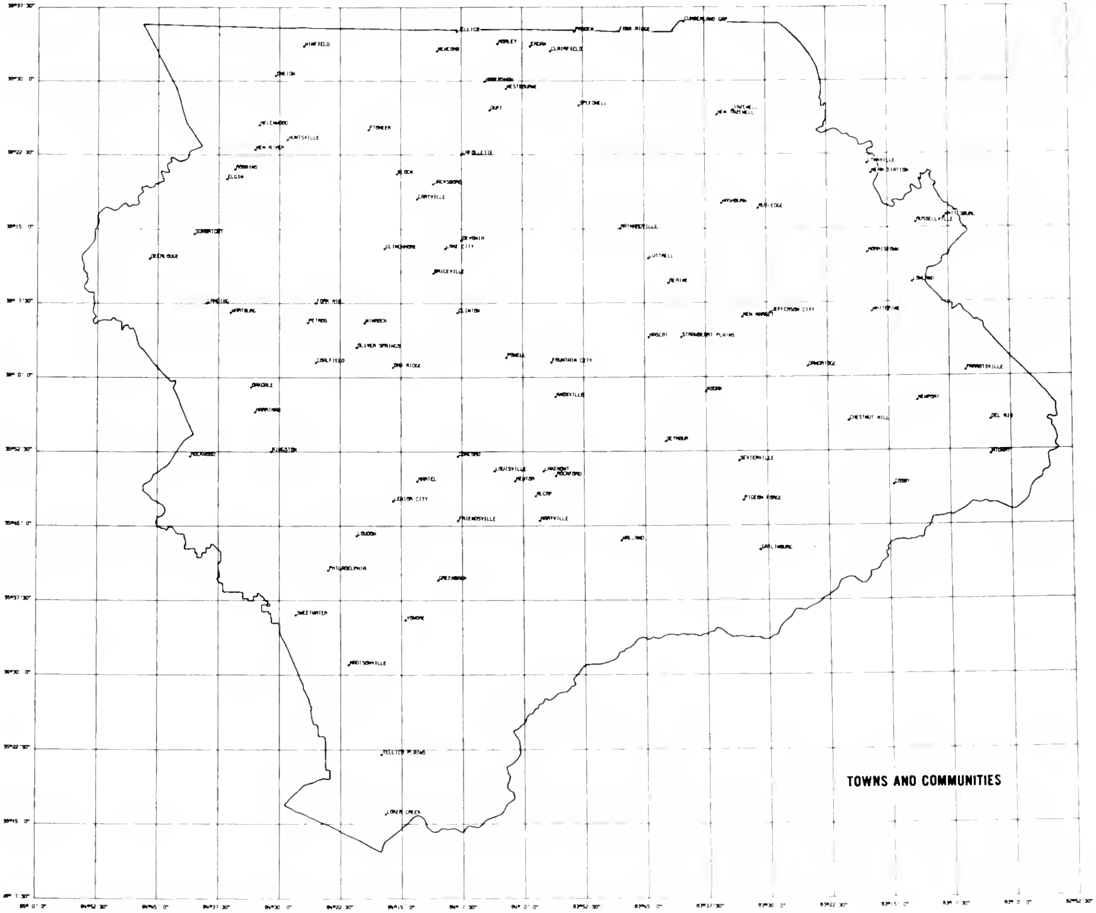
[3] Industries are referred to by their Standard Industrial Code (SIC) number throughout this study.



Three - Dimensional Relief of the East Tennessee Region

PHYSIOGRAPHY

Figure 4.


TOWNS AND COMMUNITIES
36°37'30"
36°30' 0"
36°22'30"
36°15' 0"
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82°52'30"
JELLICO
FORK RIDGE
CUMBERLAND GAP
WINFIELD
NEWCOMB
MORLEY
EAGAN
CLAIRFIELD
ONEIDA
WESTBOURNE
DUFF
SPEEDWELL
TAZEWELL
NEW TAZEWELL
HELENWOOD
HUNTSVILLE
PIONEER
NEW RIVER
LA FOLLETTE
ROBBINS
ELGIN
JACKSBORO
CARYVILLE
SUNBRIGHT
DEER LODGE
DEVONIA
CLINCHMORE
LAKE CITY
BRICEVILLE
LANCING
WARTBURG
PETROS
WINDROCK
CLINTON
OLIVER SPRINGS
COALFIELD
OAK RIDGE
POWELL
FOUNTAIN CITY
KNOXVILLE
OAKDALE
HARRIMAN
ROCKWOOD
KINGSTON
CONCORD
LOUISVILLE
LAKEMONT
ROCKFORD
MARTEL
MENTOR
LENOIR CITY
ALCOA
FRIENDSVILLE
MARYVILLE
LOUDON
PHILADELPHIA
GREENBACK
SWEETWATER
VONORE
MADISONVILLE
TELLICO PLAINS
COKER CREEK
BEAN STATION
RUTLEDGE
MAYNARDVILLE
LUTTRELL
BLAINE
RUSSELLVILLE
WHITESBURG
MORRISTOWN
LOWLAND
WHITE PINE
JEFFERSON CITY
NEW MARKET
MASCOT
STRAWBERRY PLAINS
DANDRIDGE
PARROTTSVILLE
KODAK
NEWPORT
CHESTNUT HILL
DEL RIO
SEYMOUR
SEVIERVILLE
COSBY
PIGEON FORGE
WALLAND
GATLINBURG

Figure 5.

dictated more by the distribution of raw materials and consequently the locational criteria of these industries will be different from secondary industries. For this reason primary industry is not considered in this study.

Categorically one could state that most of the industry within the region is concentrated in the Knoxville area. Of the 1002 industries in the region, approximately 46 percent are located in the immediate vicinity of Knoxville. Knoxville also has the greatest diversity of industry, whereas industry in other communities is characterized by specific categories. (An example is the concentration of furniture industry in Morristown.)

Figures 6 through 13 provide a visual overview of the dynamics of industrial development in the region since 1943. Since 1953 a 48 percent turnover in industry has occurred. Of the 1002 industries within the region in 1973, 488 have developed in the 16-county region since 1953.

Table 7 provides a statistical summary of the new industry-new employment expansion (or decline) from 1952 to 1973. The table does not reflect the absolute employment expansion rate but rather the amount of employment gained or lost by the birth or death of specific two-digit SIC industries. A high average expansion rate indicates new plants have developed in the region and have significantly increased the total employment in that specific industry.

In the following discussion each industry type is briefly described. Maps are included to show the regional distribution of specific industries. Graphs illustrating the historical employment

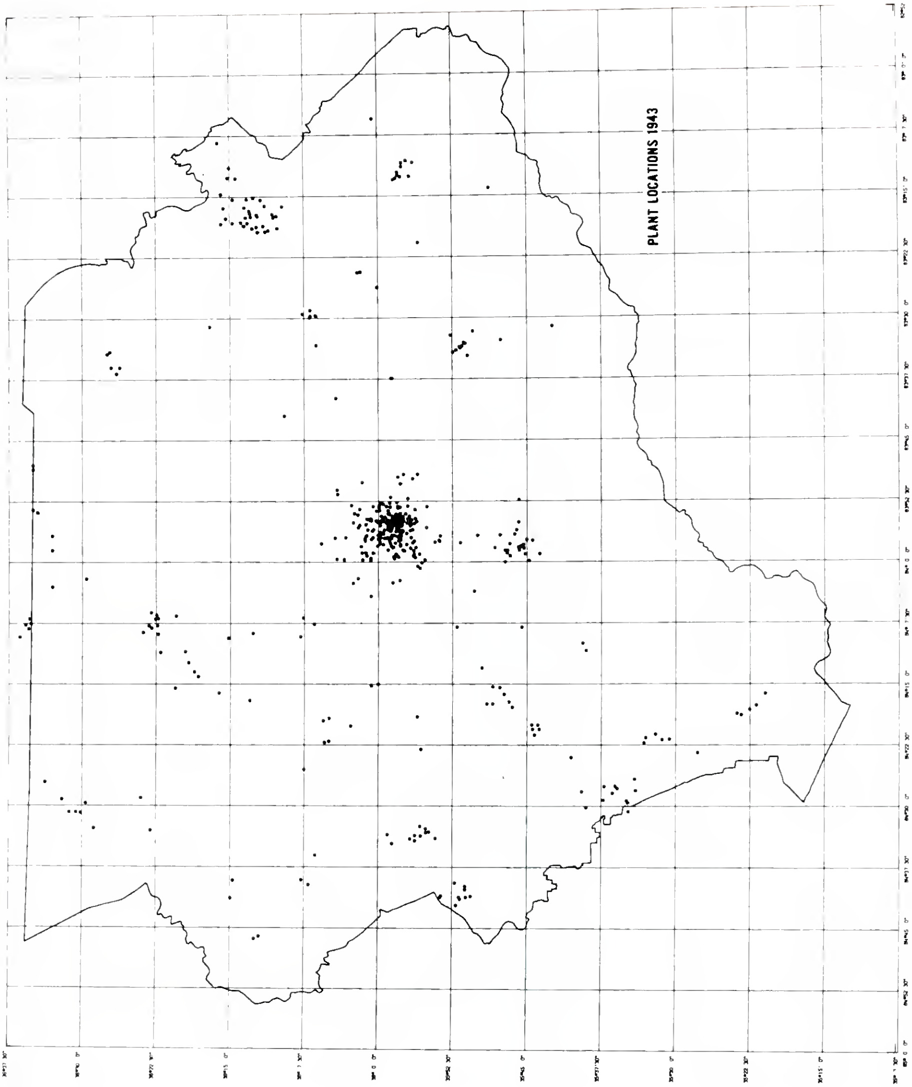


Figure 6.

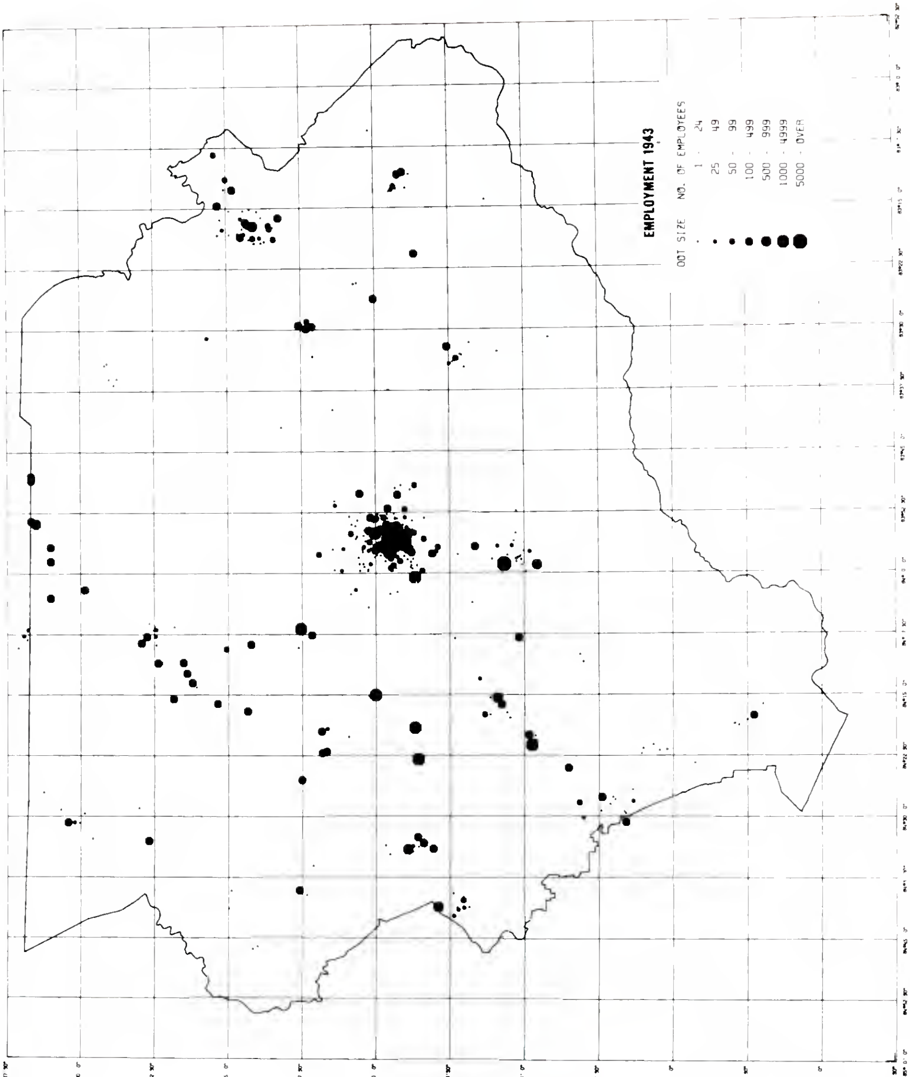
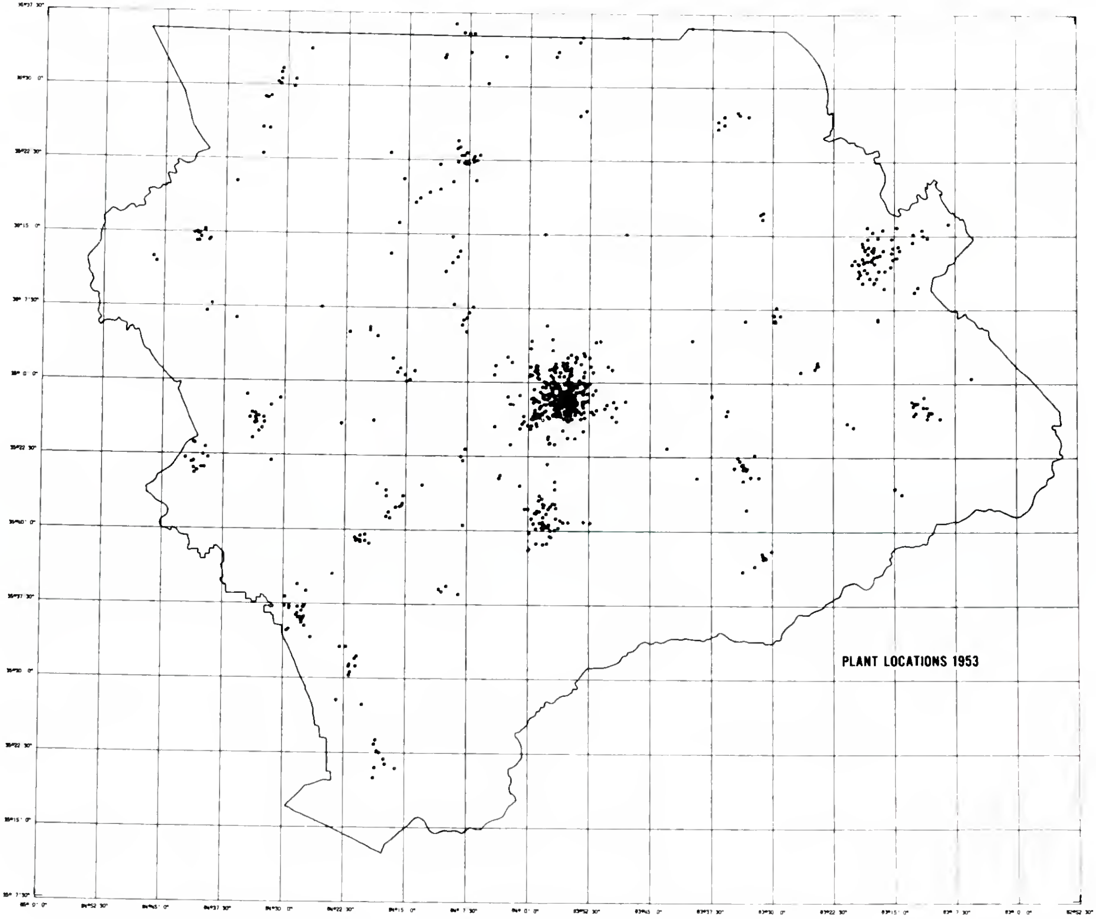

EMPLOYMENT 1943
DOT SIZE NO. OF EMPLOYEES
• 1 - 24
● 25 - 49
● 50 - 99
● 100 - 499
● 500 - 999
● 1000 - 4999
● 5000 - OVER

Figure 7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36°15'0"
36°7'30"
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35°52'30"
35°45'0"
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83°7'30"
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Figure 8.

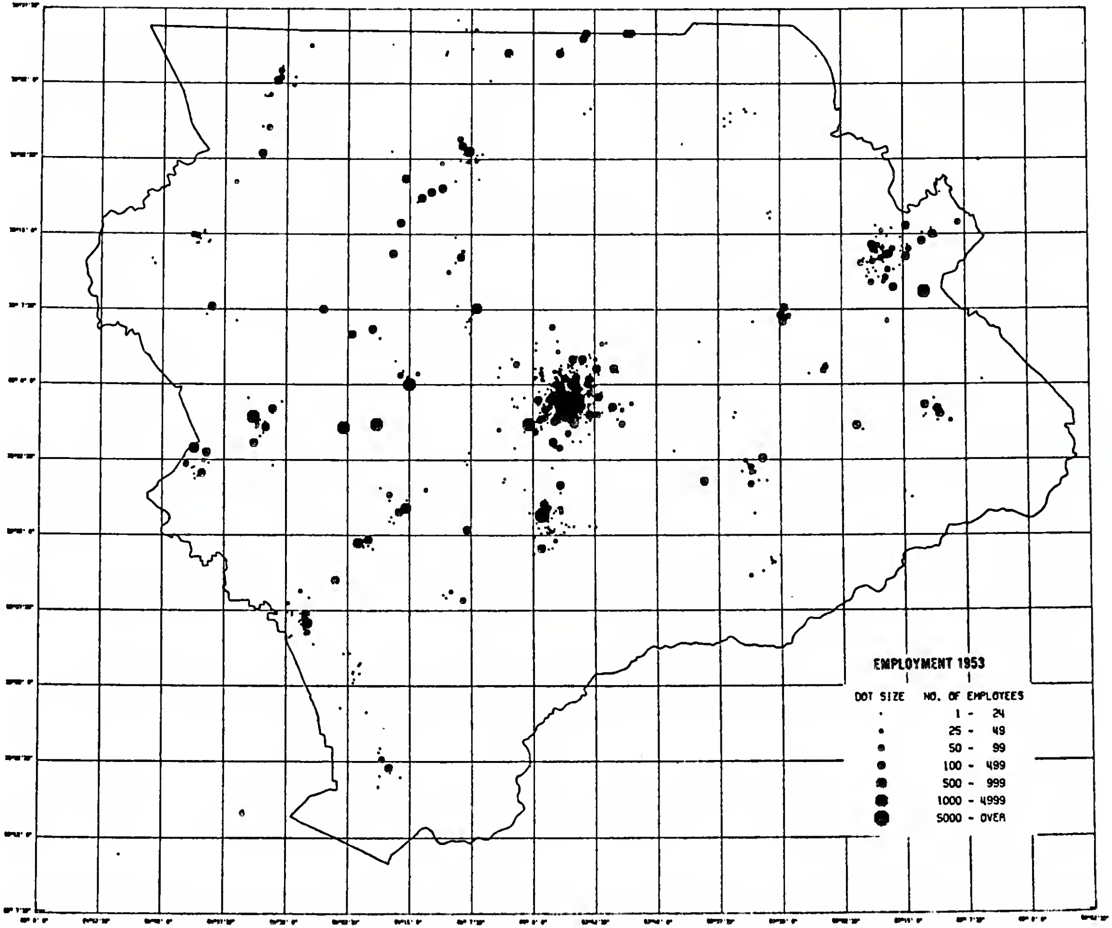
EMPLOYMENT 1953
DOT SIZE
NO. OF EMPLOYEES
1 - 24
25 - 49
50 - 99
100 - 499
500 - 999
1000 - 4999
5000 - OVER

Figure 9.

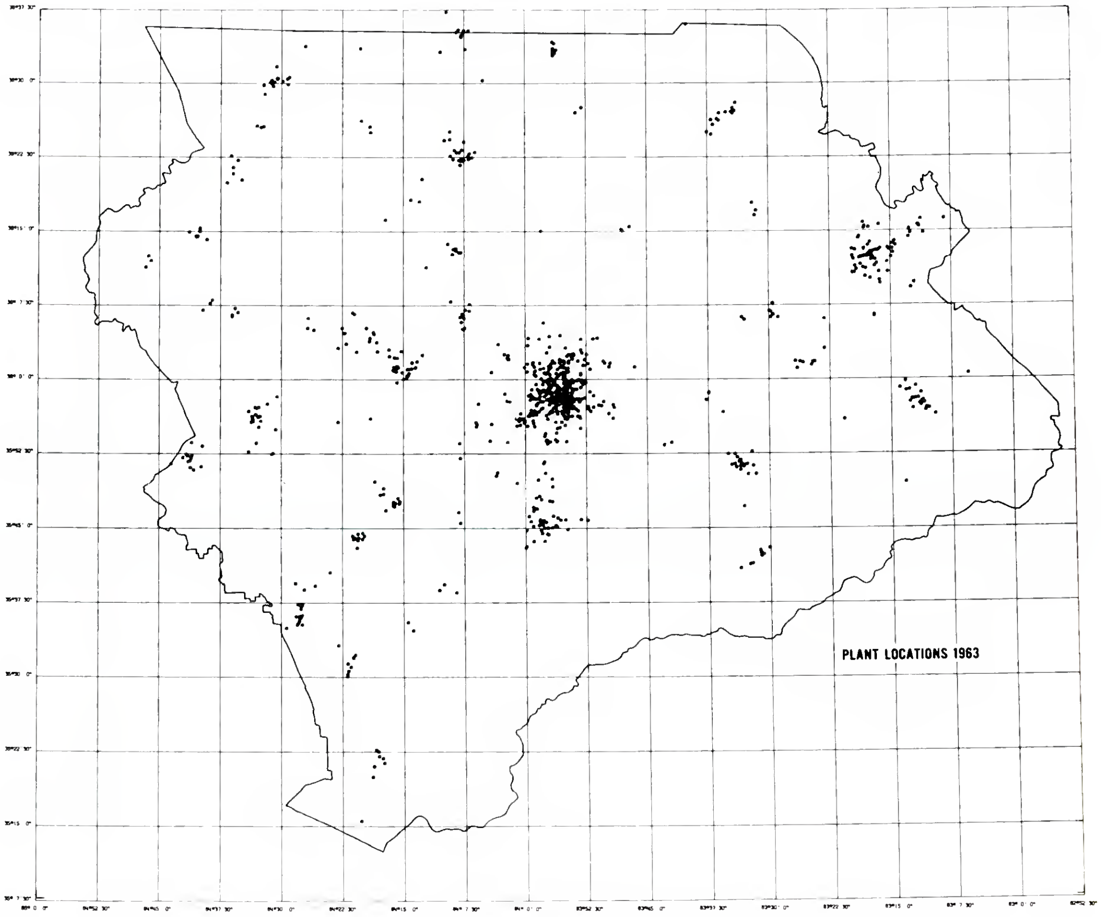
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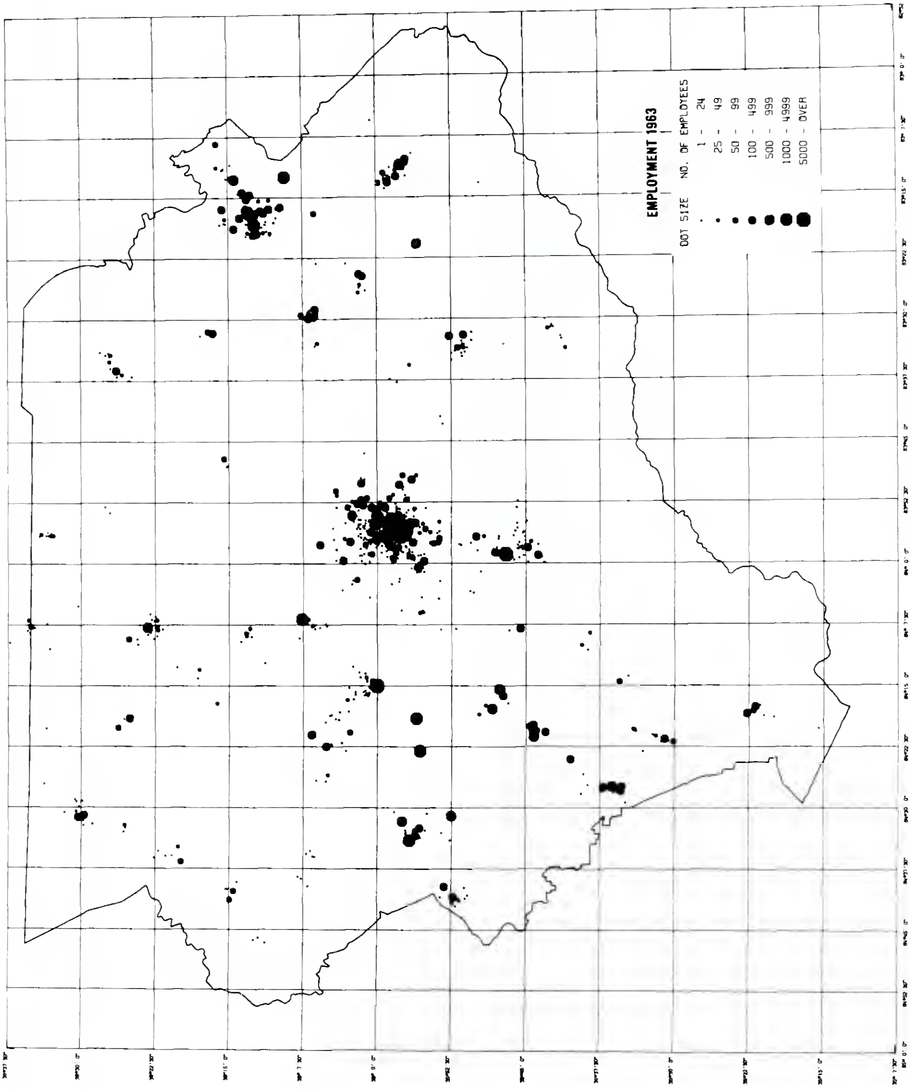
Figure 10.


EMPLOYMENT 1963
DOT SIZE
NO. OF EMPLOYEES
1 - 24
25 - 49
50 - 99
100 - 499
500 - 999
1000 - 4999
5000 - OVER
38°37'30"
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38° 7'30"
38° 0' 0"
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Figure 11.

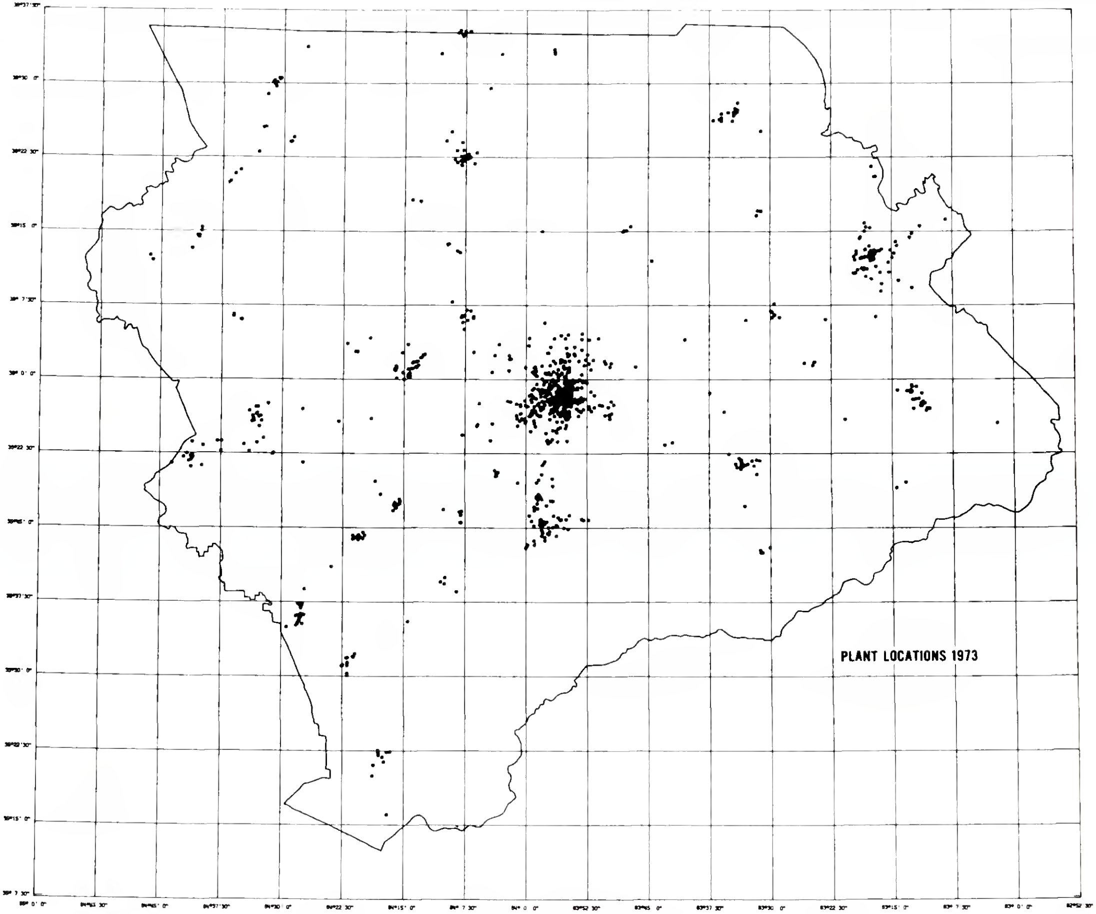
PLANT LOCATIONS 1973
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Figure 12.

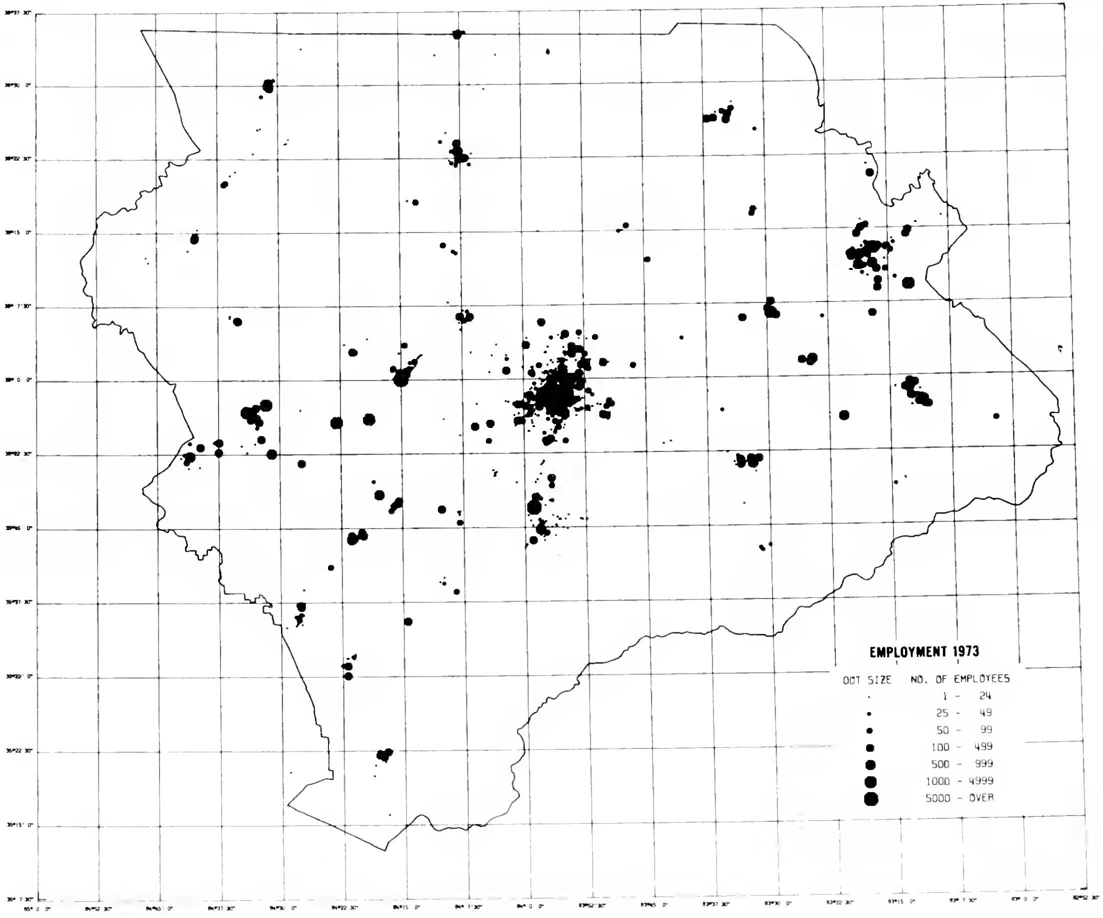
EMPLOYMENT 1973
DOT SIZE
NO. OF EMPLOYEES
1 - 24
25 - 49
50 - 99
100 - 499
500 - 999
1000 - 4999
5000 - OVER
85° 0' 0"
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Figure 13.

Industry by SIC	1955	1958	1960	1963	1966	1969	1973	Average New Expansion Rate 1952-1973
20 Food	+9.4	+10.0	+0.5	+8.7	+6.5	-3.2	+11.8	+3.8
21 Tobacco								
22 Textile	-4.6	-2.7	-7.5	+8.3	-3.9	+5.2	-19.7	-3.6
23 Apparel	+28.3	-13.6	+2.3	+11.2	+20.1	+40.3	-12.4	+10.9
24 Lumber	-40.4	-3.2	-2.2	-0.3	+2.1	-7.2	+11.2	-5.7
25 Furniture	+24.0	+30.4	+53.1	+5.2	+13.8	+5.9	+7.8	+20.0
26 Paper	-4.7	-16.4	+12.3	+4.2	+10.2	+49.1	+41.8	+13.8
27 Printing	+9.3	-2.0	+24.5	+2.2	-4.1	+21.0	-3.3	+6.8
28 Chemical	-.6	+13.4	-4.3	-14.7	+2.3	-2.4	-25.6	+2.8
29 Petroleum	-8.2	+4.7	+5.2	+27.2	-41.9	+43.0	-5.0	+3.6
30 Rubber	-1.4	-11.6	+9.8	+79.5	+10.3	+61.6	-32.4	+16.5
31 Leather	-9.7	-7.1	+25.8	+25.9	+13.1	+62.6	+63.5	+24.6
32 Stone, Glass, Etc.	+1.4	+3.2	+7.6	+.3	-11.0	-4.4	+25.5	+3.2
33 Primary Metals	-6.9	+10.1	+.5	-22.8	-4.6	-6.9	-2.4	-4.7
34 Fabricated Metals	+36.6	+12.0	+.8	+10.1	+4.7	+36.8	+6.3	+15.3

EXPANSION OF ETDD INDUSTRIES BETWEEN 1952-1973

TABLE 7

Industry by SIC	1955	1958	1960	1963	1966	1969	1973	Average New Expansion Rate 1952-1973
35 Machinery Non-Electric	-3.4	+15.2	-8.6	+3.1	-15.0	+55.3	+0.5	+6.7
36 Electrical Machinery	-47.7	+1.3	-6.9	+409.8	+21.1	+30.1	+19.1	+60.9
37 Transportation	+26.4	-17.2	+22.5	+3.7	+439.0	-13.2	+136.5	+85.4
38 Instrument	+37.3	-1.2	-3.9	+4.5	-1.1	+9.5	-3.3	+3.3
39 Miscellaneous	-15.7	+2.6	-8.4	+34.5	+4.4	+11.6	-26.1	+10.6

*This table is based upon ORNL industrial location data. Expansion rates are determined on the basis of new employment prompted by new plants (or death of plants) since the previous time period. The base year is 1952.

TABLE 7 - Continued

trends relative to total regional employment and the industry's share of total regional manufacturing employment accompany each map.[4]

Food products industries (SIC 20)[5]

Of the 103 plants existing within the region, 66 are located in the Knoxville region. Most of the remaining plants are located in the southern half of the region bordering the Smoky Mountains near the better crop producing areas along the margins of the Nolichucky, Pigeon, Little Tennessee, and the French Broad Rivers (Figure 14). Approximately 75 percent of these industries employ less than 100 persons. Employment growth has been gradual and in accord with total regional growth. Proportionally, however, employment has been declining (Figure 15).

Tobacco products industries (SIC 21)

No tobacco industries exist within the study region.

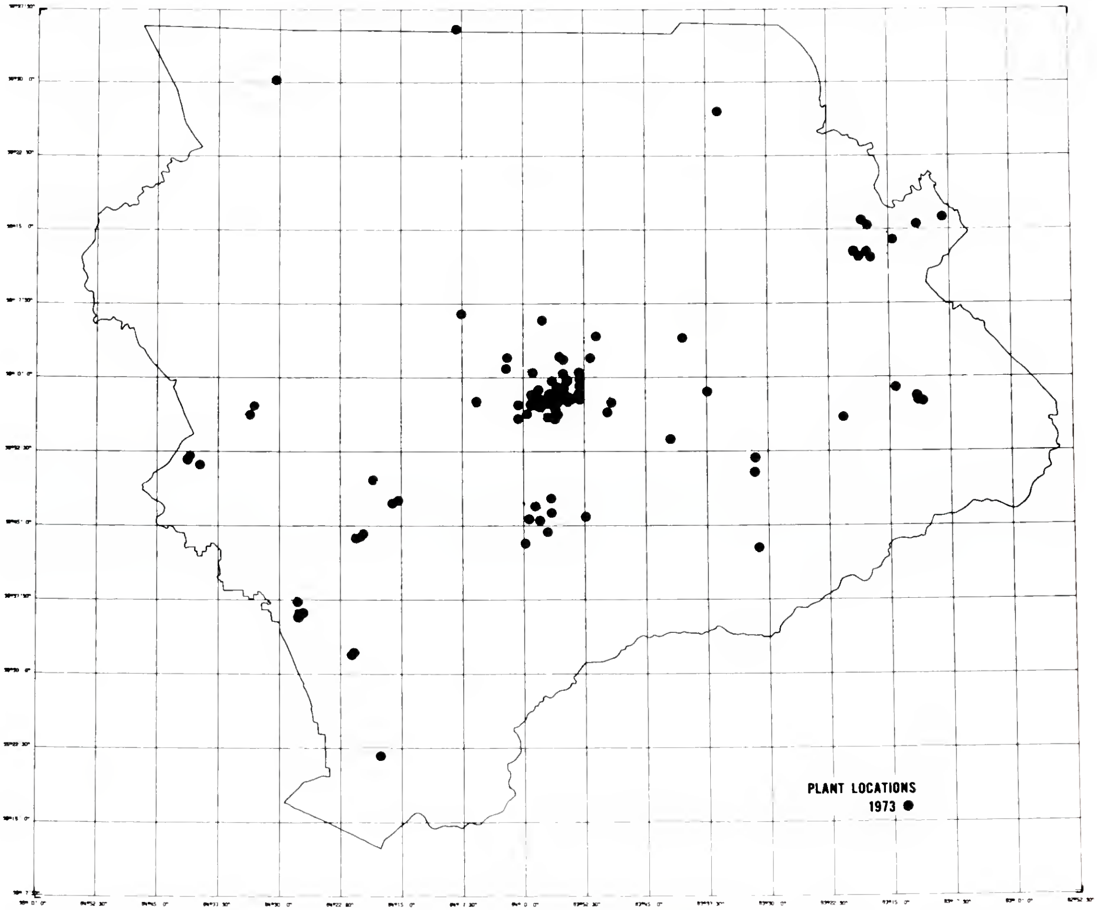
Textile mill products industries (SIC 22)

The textile industry is distributed broadly from northeast to southwest through the center of the region with Knoxville having the greatest concentration followed by Morristown and Sweetwater (Figure

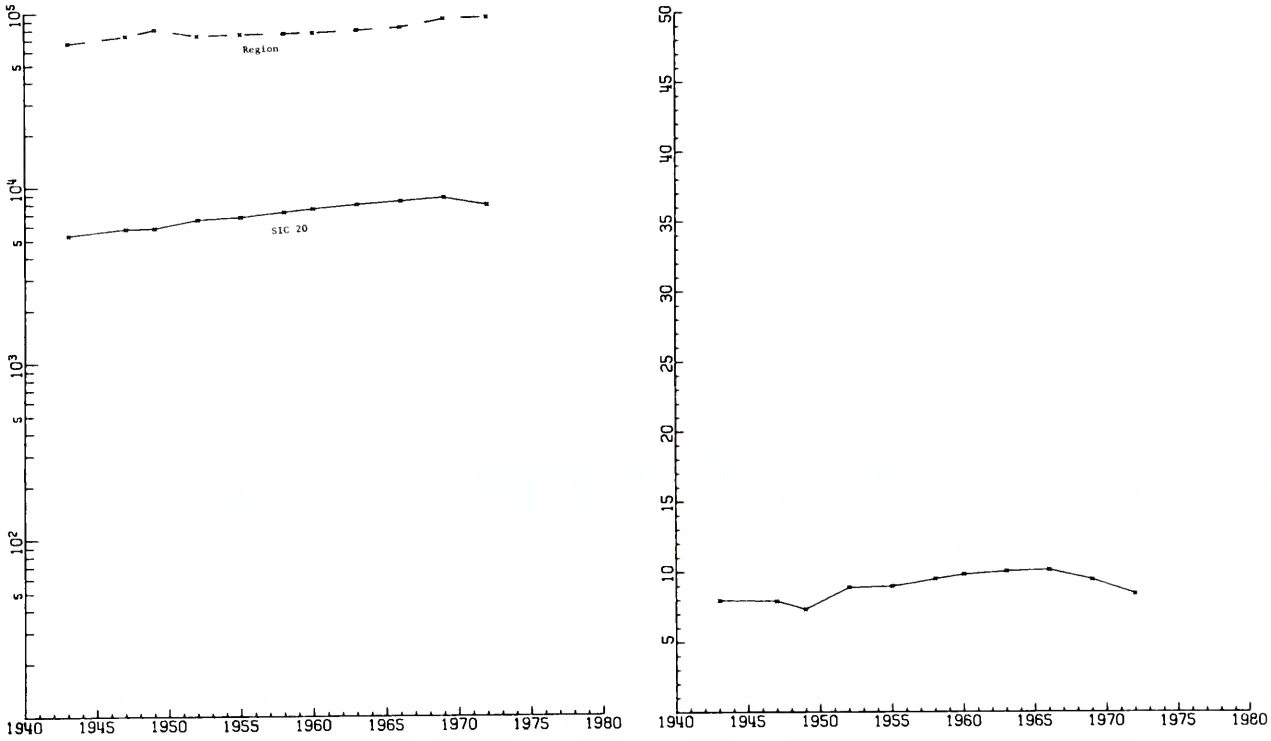
---

[4] The maps and graphs utilized in this chapter were prepared by a CALCOMP plotter driven by an IBM 360 computer. The data utilized were originally collected by Osbin L. Ervin. For a complete presentation of these data, see: C. R. Meyers, Jr., O. L. Ervin, D. L. Wilson, and P. A. Lesslie, Spatial Distributions and Employment Trends of Manufacturing Industries in East Tennessee (1943-1973) (Oak Ridge, Tennessee, Oak Ridge National Laboratory, June, 1974).

[5] Transparent overlays found in Appendix B may be superimposed over each industry map for spatial referencing.



SIC 20 - FOOD PRODUCTS
Figure 14.



EMPLOYMENT IN SIC 20 AND IN
TOTAL REGIONAL MANUFACTURING

SIC 20's SHARE OF REGIONAL
MANUFACTURING EMPLOYMENT (PERCENT)

SIC 20 - FOOD PRODUCTS
Figure 15.

16). Average employment in the industry is approximately 210 persons per plant. Rockwood and Harriman have only four plants but share nearly 50% of the total employment in the region. The distribution of plants reflects a tendency to gravitate to relatively small communities as suggested by Lonsdale[6] and Pred.[7] Textile industry has declined in terms of the percent of total regional employment in recent years perhaps resulting from the introduction of higher wage industry into the region (Figure 17).

Clothing and related products (SIC 23)

Knoxville leads the area with the greatest concentration in both plants and employment (Figure 18). Average employment is approximately 315 persons; however, the median is closer to 150 employees. This type of industry though concentrated in Knoxville is scattered throughout the region with numerous small communities having at least one (sometimes two or three) small employment industry. In terms of new industry expansion the clothing industry expanded at an average rate of 10.9 percent between 1953 and 1973. Historically, however, growth has been erratic (Figure 19).

Lumber and wood products except furniture (SIC 24)

This industry is widely scattered throughout the region mostly in small communities (Figure 20). It is a small employment industry mainly utilizing local raw materials. In recent years, an overall

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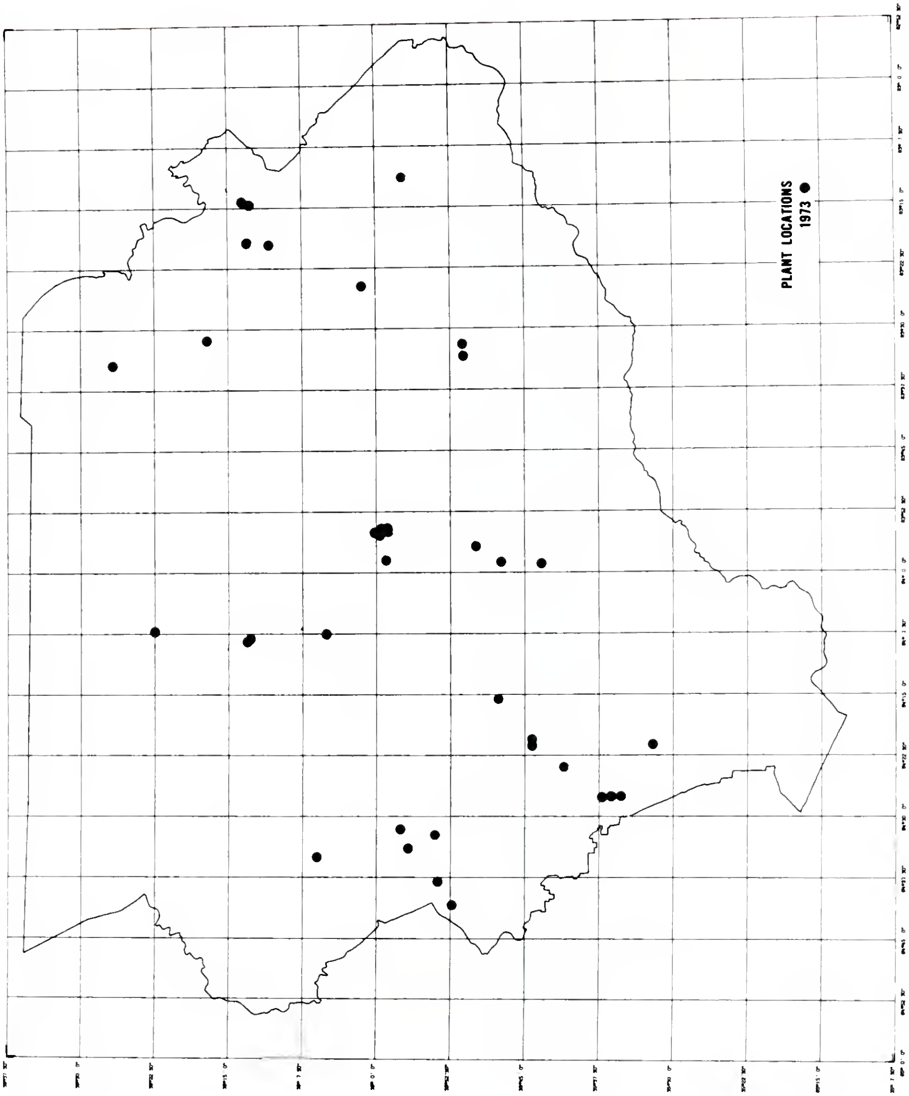
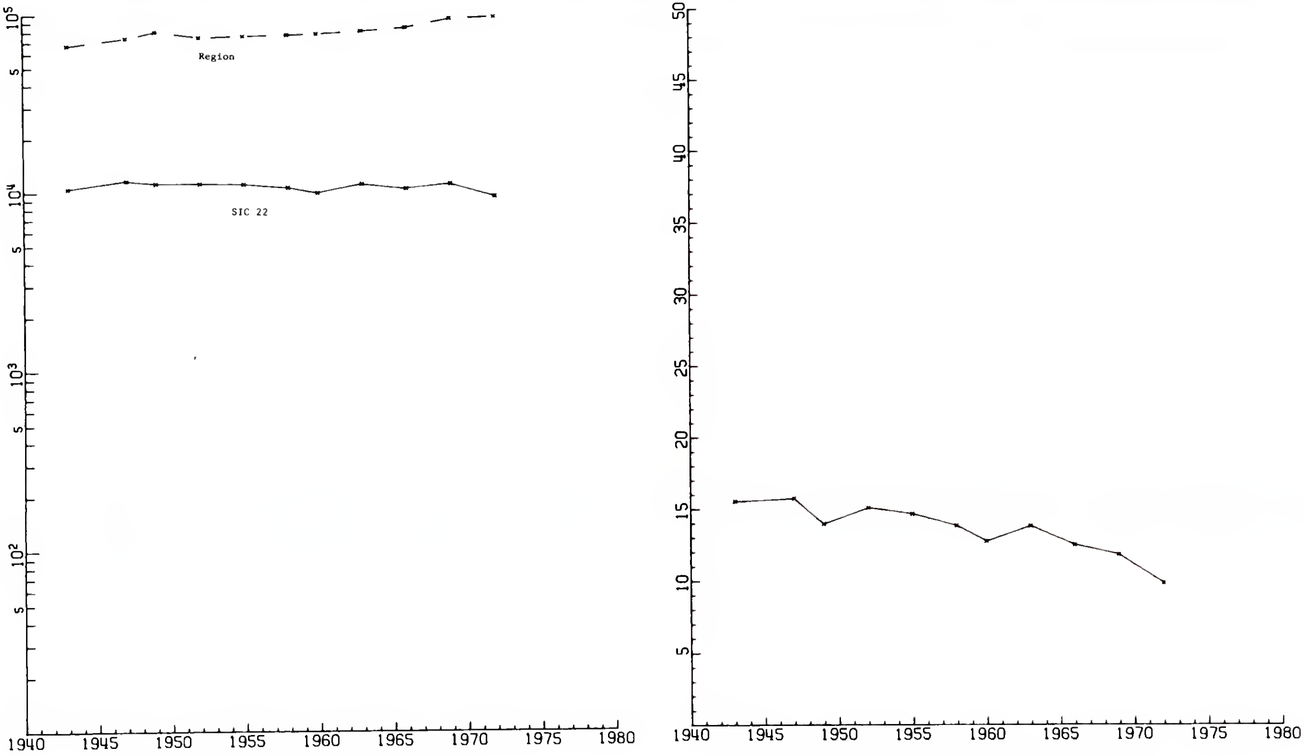
[6] Richard E. Lonsdale, cited in Chapter 2.

[7] Allen Pred, cited in Chapter 2.



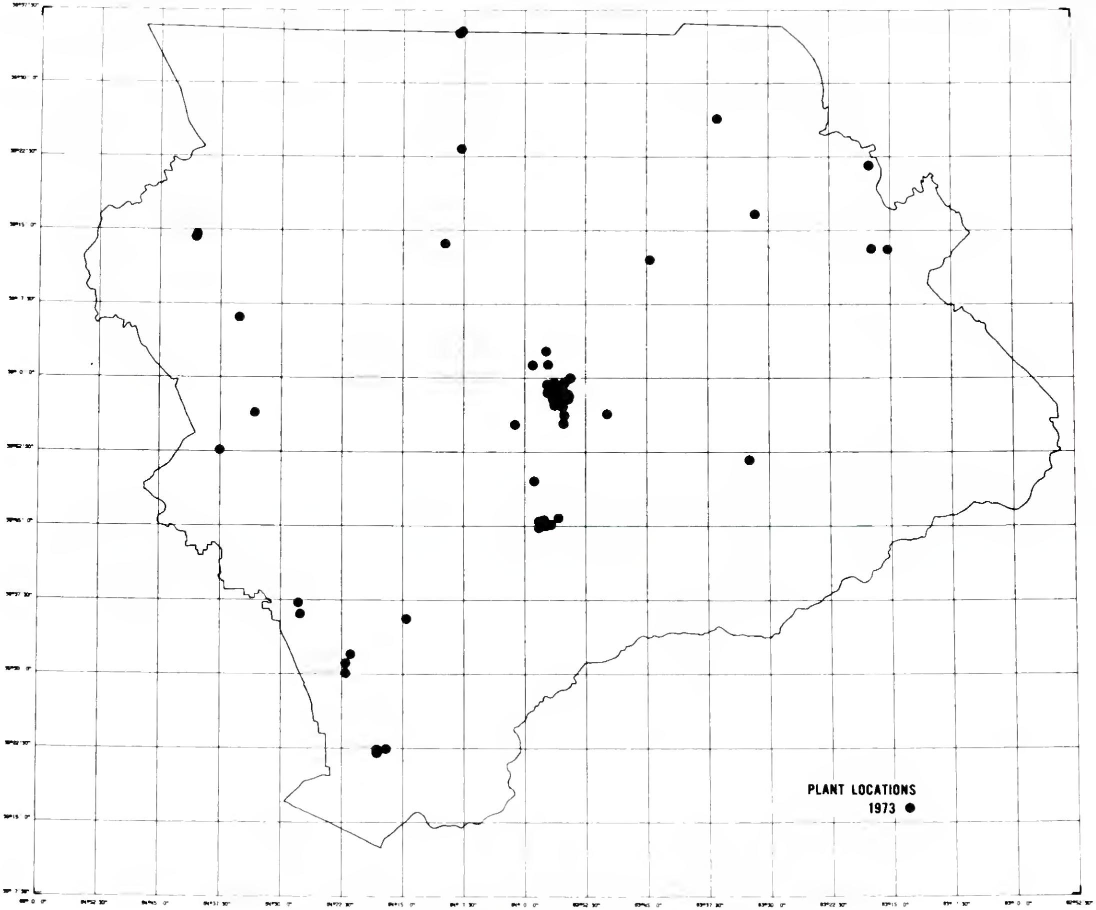
SIC 22 - TEXTILE MILL PRODUCTS
Figure 16.



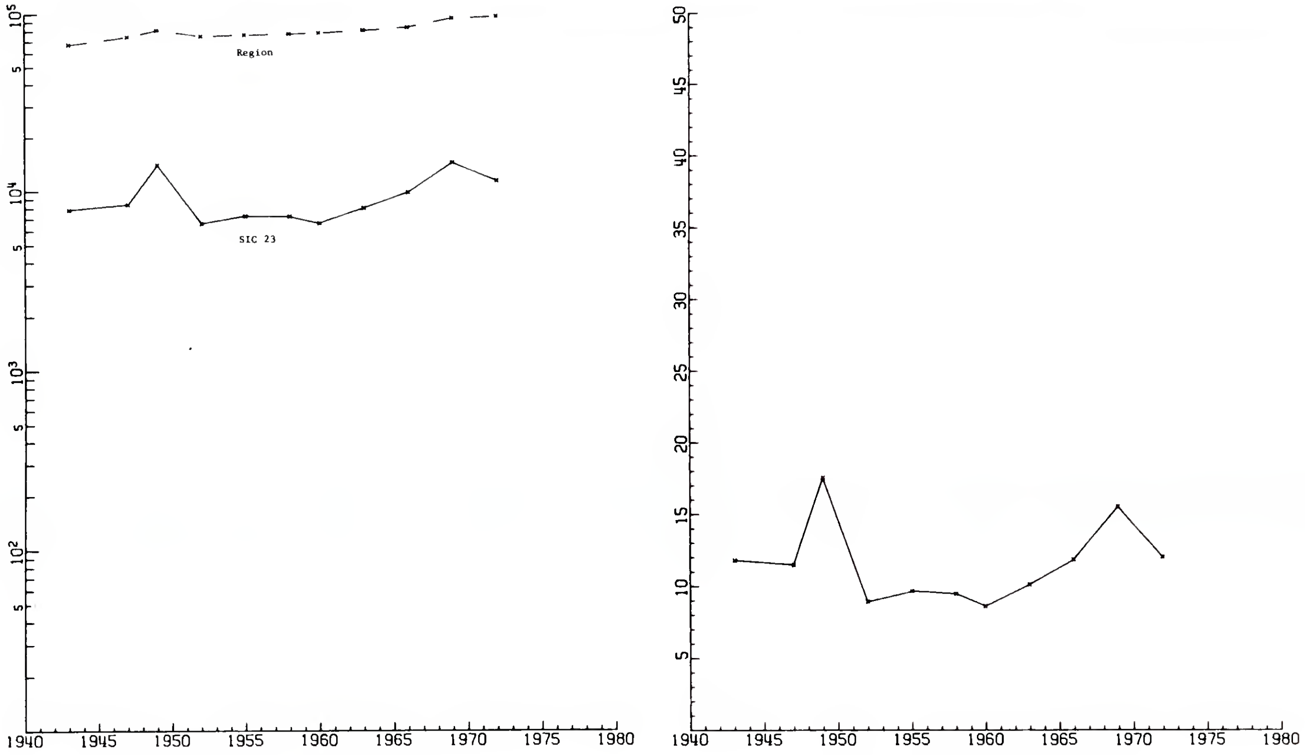
EMPLOYMENT IN SIC 22 AND IN
TOTAL REGIONAL MANUFACTURING

SIC 22's SHARE OF REGIONAL
MANUFACTURING EMPLOYMENT (PERCENT)

SIC 22 - TEXTILE MILL PRODUCTS
Figure 17.



SIC 23 - APPAREL AND RELATED PRODUCTS
Figure 18.

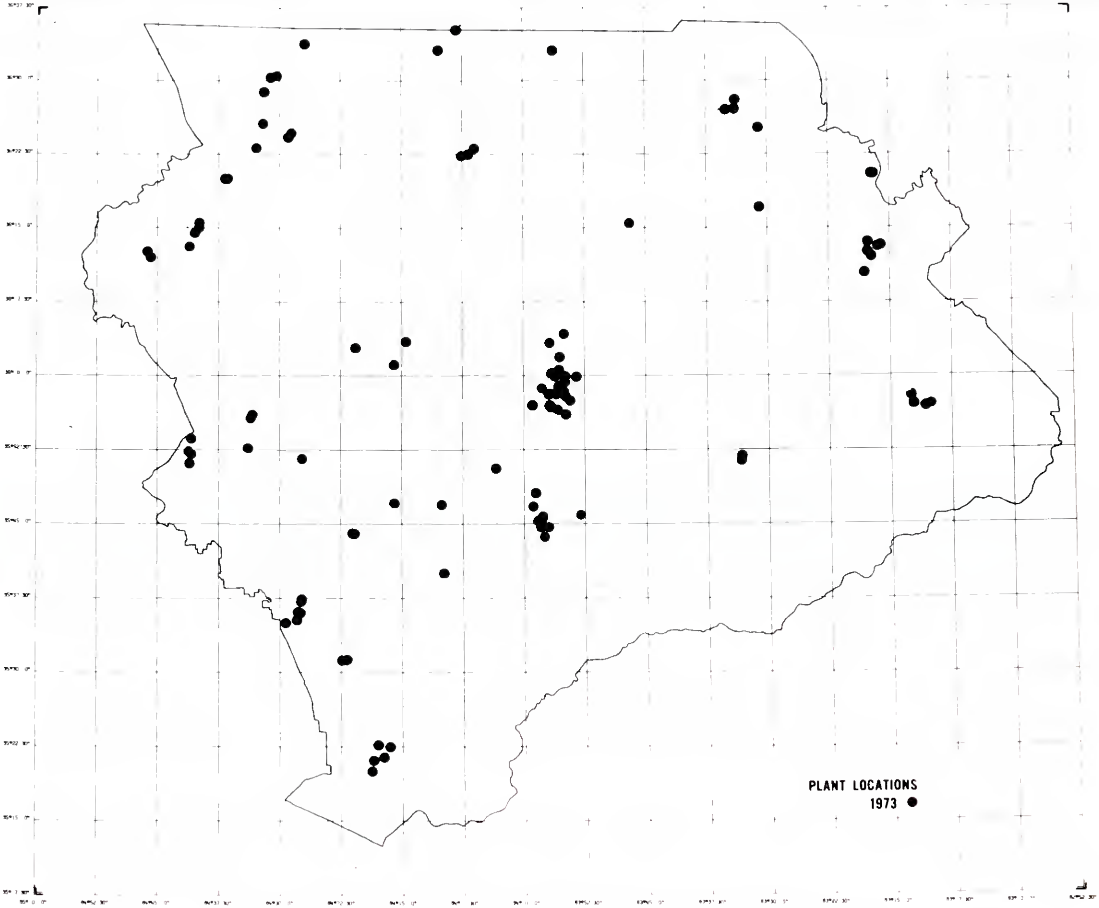


EMPLOYMENT IN SIC 23 AND IN
TOTAL REGIONAL MANUFACTURING

SIC 23's SHARE OF REGIONAL
MANUFACTURING EMPLOYMENT (PERCENT)

SIC 23 - APPAREL AND RELATED PRODUCTS

Figure 19.



SIC 24 - LUMBER AND WOOD PRODUCTS (except furniture)
Figure 20.

decline in the industry has occurred partly due to a decline in small-operated lumbering in general for the region. The average employment per plant is only 32 persons with the median closer to 15 persons per plant.

The growth prospects for this industry are rated good by the TVA Regional Planning Office but it is expected to be in terms of large, permanent sawmills utilizing local oak, hickory, and poplar forest resources (Figure 21). Those species are being increasingly utilized by the furniture manufacturers.[8]

Furniture and fixtures industries (SIC 25)

The furniture and related products industries (e.g. woodworking industry) is heavily concentrated in Morristown (with 20 of the 46 plants) even though Knoxville has 17 plants (Figure 22). The average number of employees per plant in Knoxville, however, is 161 persons; whereas the average in Morristown is approximately 310 persons.

The furniture industry located in Morristown not because of the local timber sources but because of cheap labor and good rail connections to large mills in the South and to market regions in the North. With increasing reliance upon local timber, however, the growth prospects for this industry are seen to be significant (Figure 23).[9]

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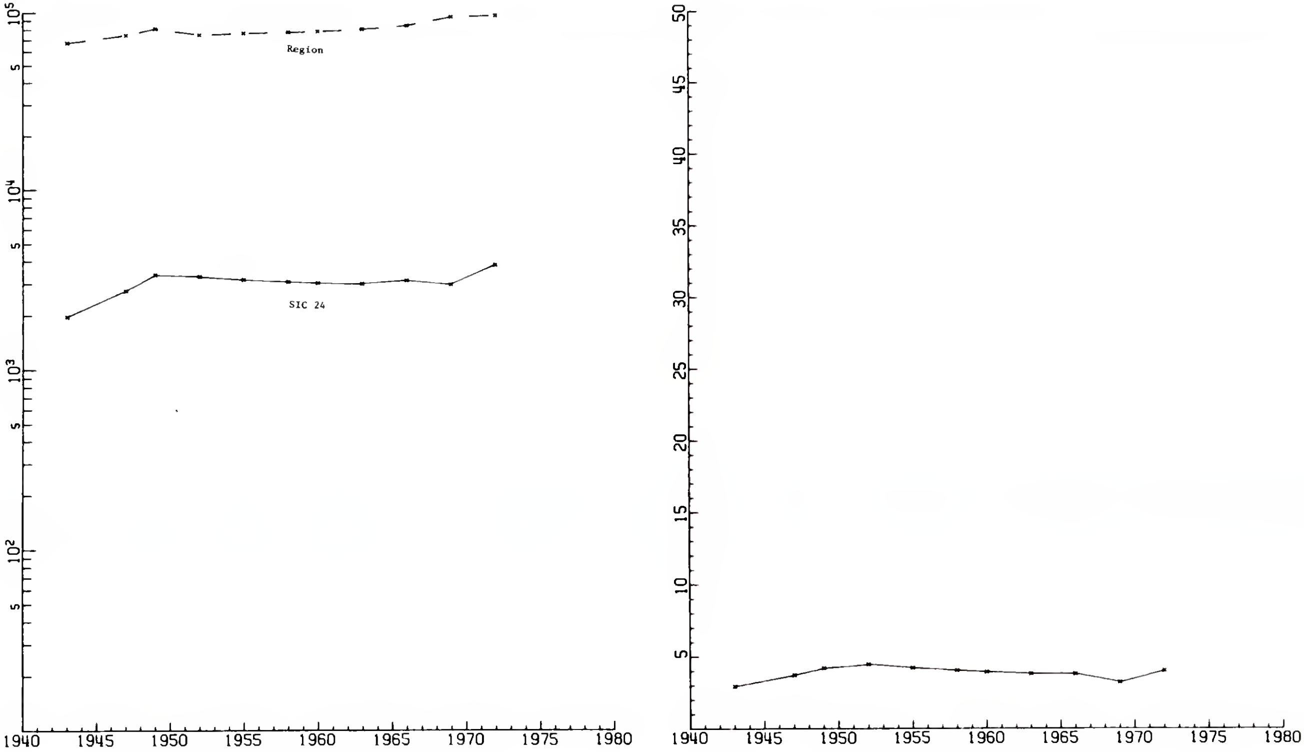
[8] Communication with Bill Ogden, TVA Regional Planning Office, Knoxville, Tennessee, May 3, 1973.

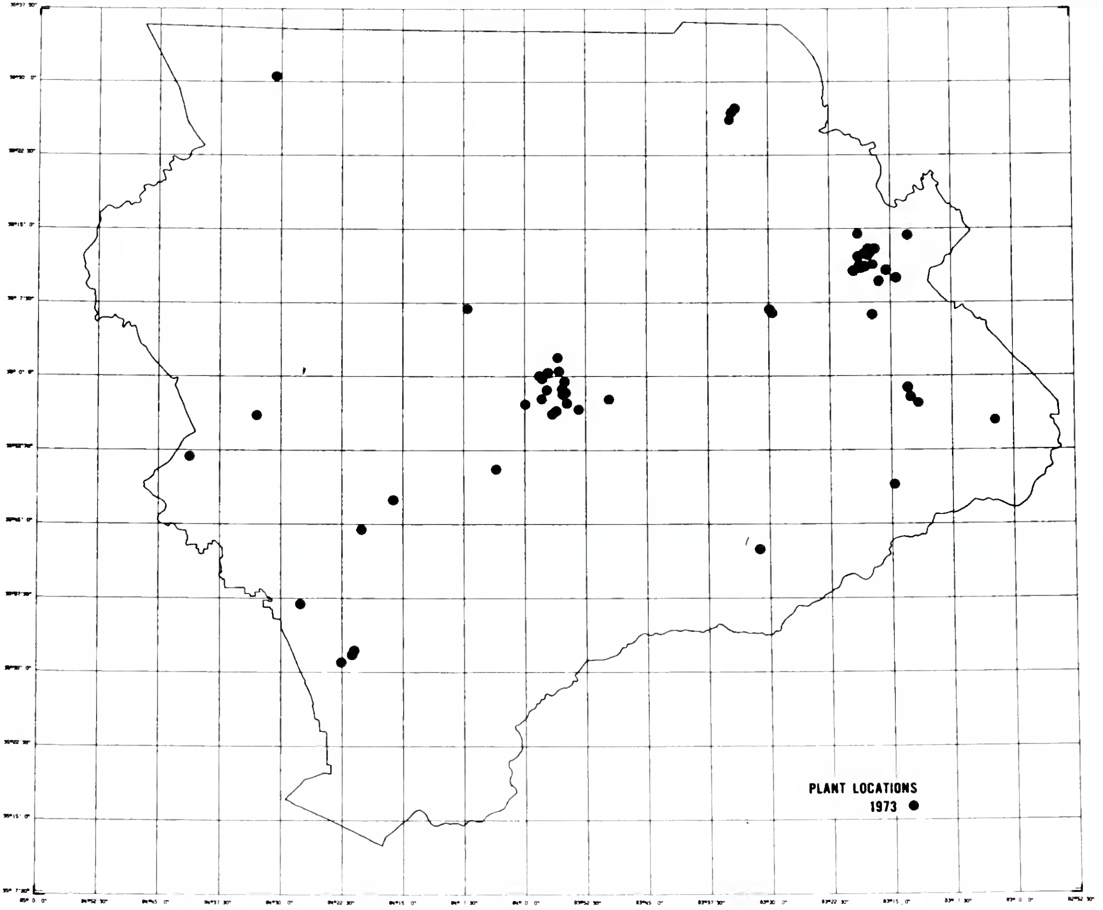
[9] Ibid.



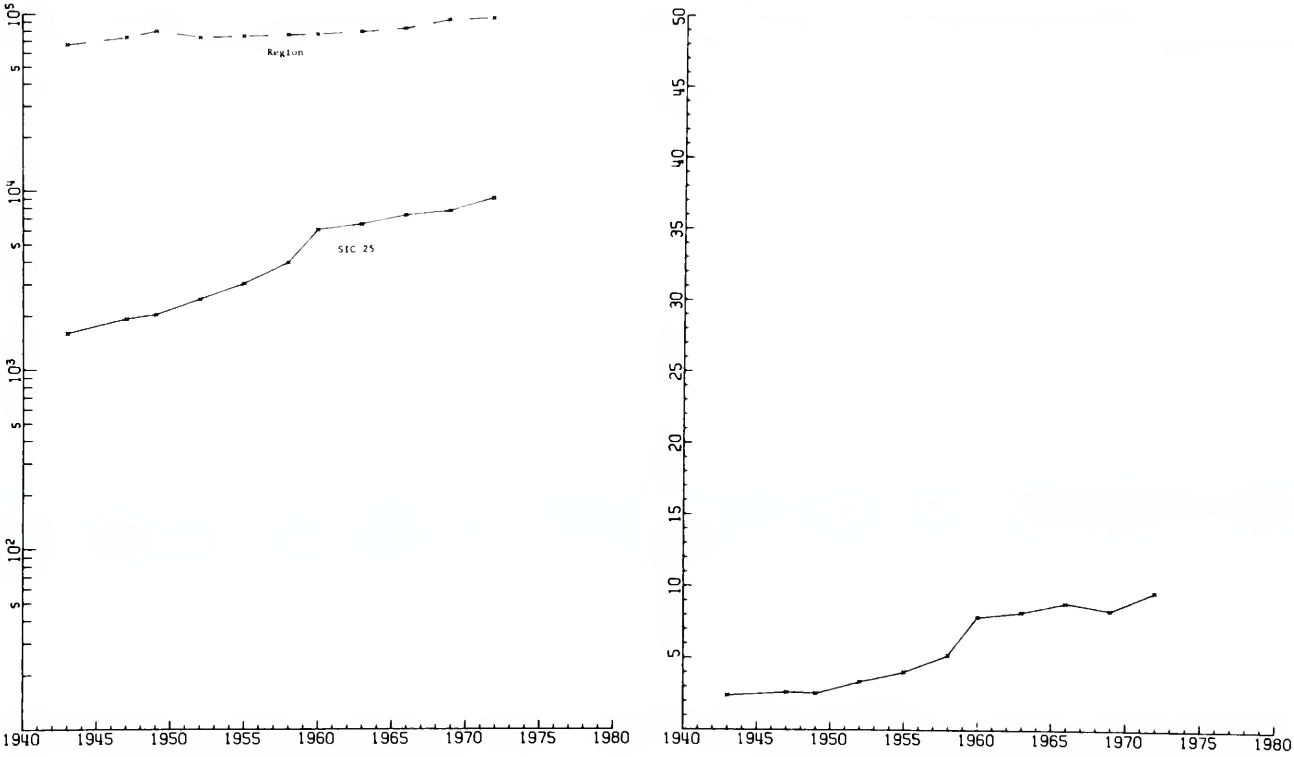
EMPLOYMENT IN SIC 24 AND IN
TOTAL REGIONAL MANUFACTURING

SIC 24's SHARE OF REGIONAL
MANUFACTURING EMPLOYMENT (PERCENT)

SIC 24 - LUMBER AND WOOD PRODUCTS (except furniture)
Figure 21.



SIC 25 - FURNITURE AND FIXTURES
Figure 22.



EMPLOYMENT IN SIC 25 AND IN
TOTAL REGIONAL MANUFACTURING

SIC 25's SHARE OF REGIONAL
MANUFACTURING EMPLOYMENT (PERCENT)

SIC 25 - FURNITURE AND FIXTURES
Figure 23.

Paper and pulp products industries (SIC 26)

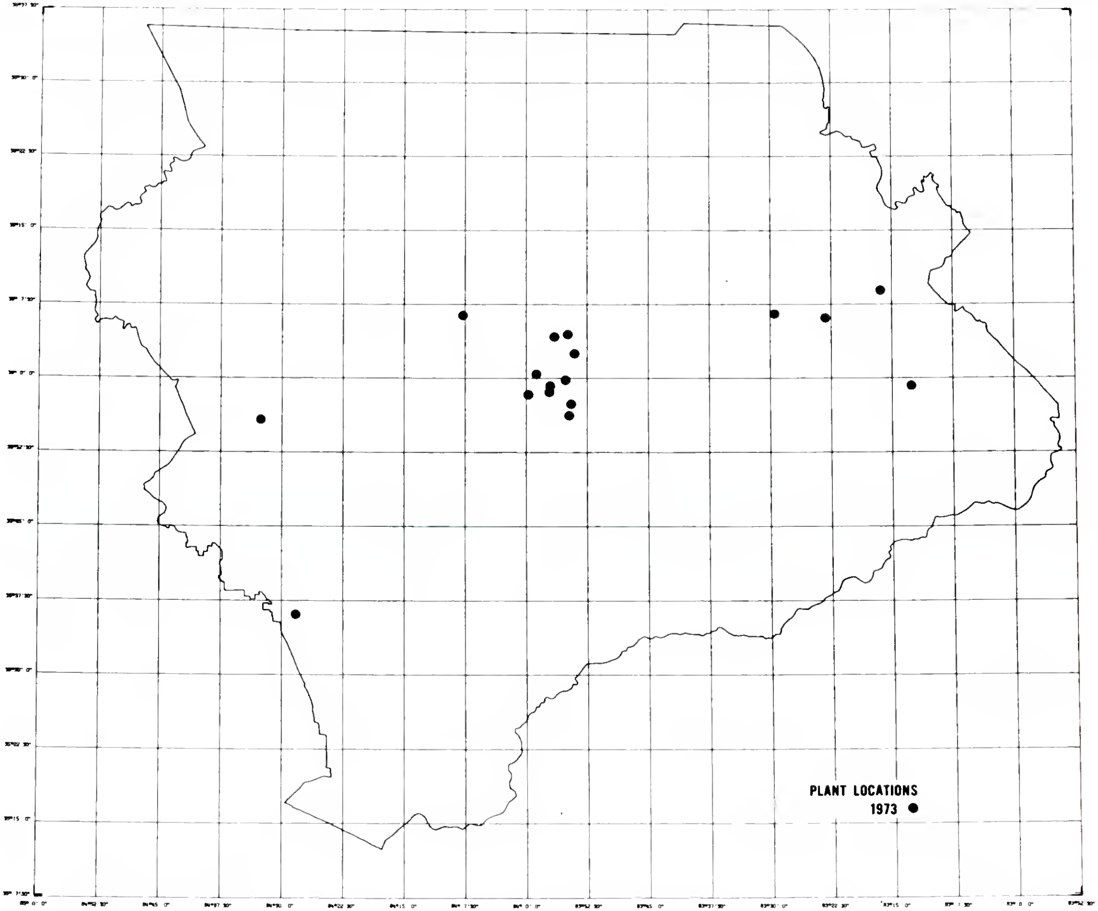
The paper and pulp industry is concentrated in the Knoxville area both in terms of employment and number of plants (Figure 24). Intuitively, one suspects market-demand to be a strong locational factor except for the plants in Morristown which are locationally related to the by-products produced by the furniture industry. Employment averages 78 persons with the largest plant employment only 190 persons. Total employment in the paper and pulp products industry is relatively low compared to other industries, only 1377 employees in 1973. The average growth rate, however, has been significant (Figure 25).

Printing and publishing industries (SIC 27)

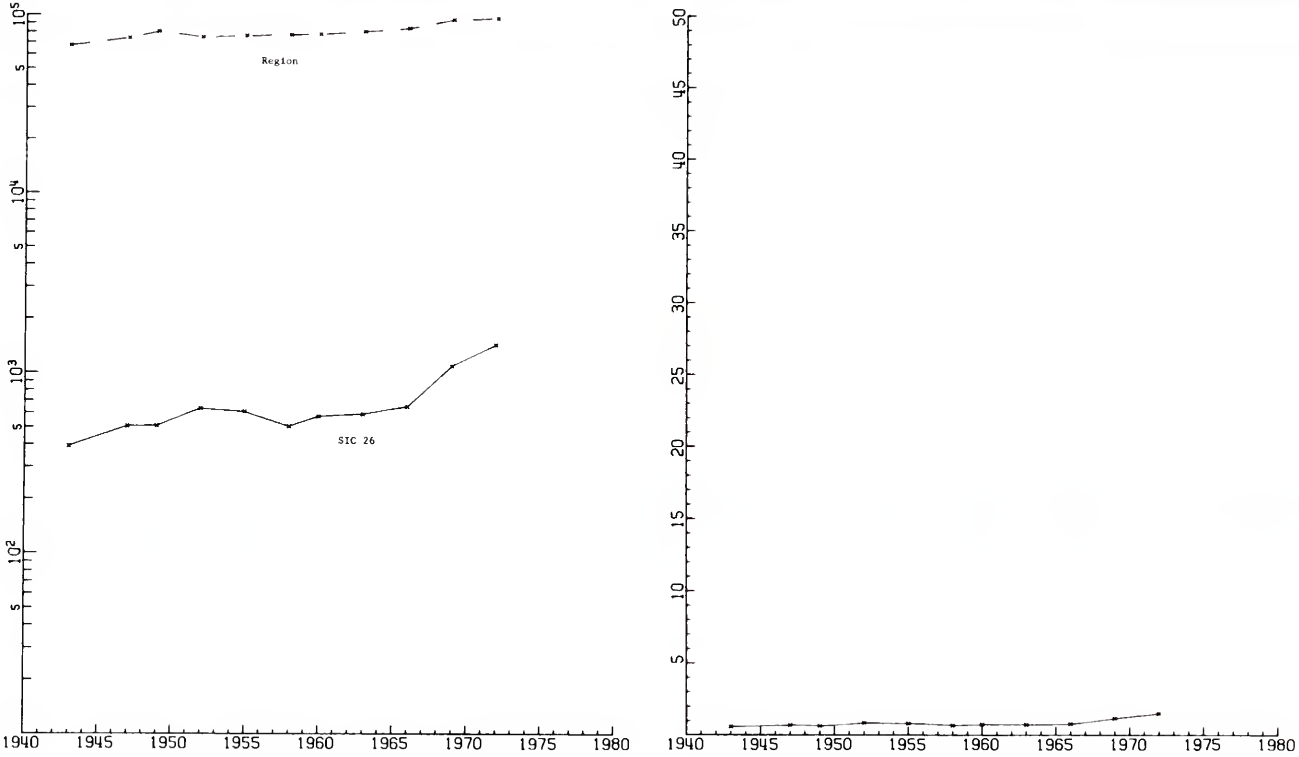
Printing and publishing includes local newspaper printing and for obvious reasons is widely dispersed throughout the 16-county region (Figure 26). Knoxville has the greatest concentration with over 75 percent of the employment and 2/3 of the total number of establishments. Total employment is low for the region (1670 employees in 1970) with an average of 19 workers per plant. Growth has increased along with population with no great expansion predicted (Figure 27).

Chemical products industries (SIC 28)

The shunning of large urban places by chemical plants noted in Chapter II at first appearance is not substantiated by the regional pattern of chemical industries within ETDD (Figure 28). Industries are found in the other communities (e.g., Morristown and Oak Ridge) but Knoxville is the leader in number of plants with all but six of the 33 plants in the region. However, the Knoxville industries are



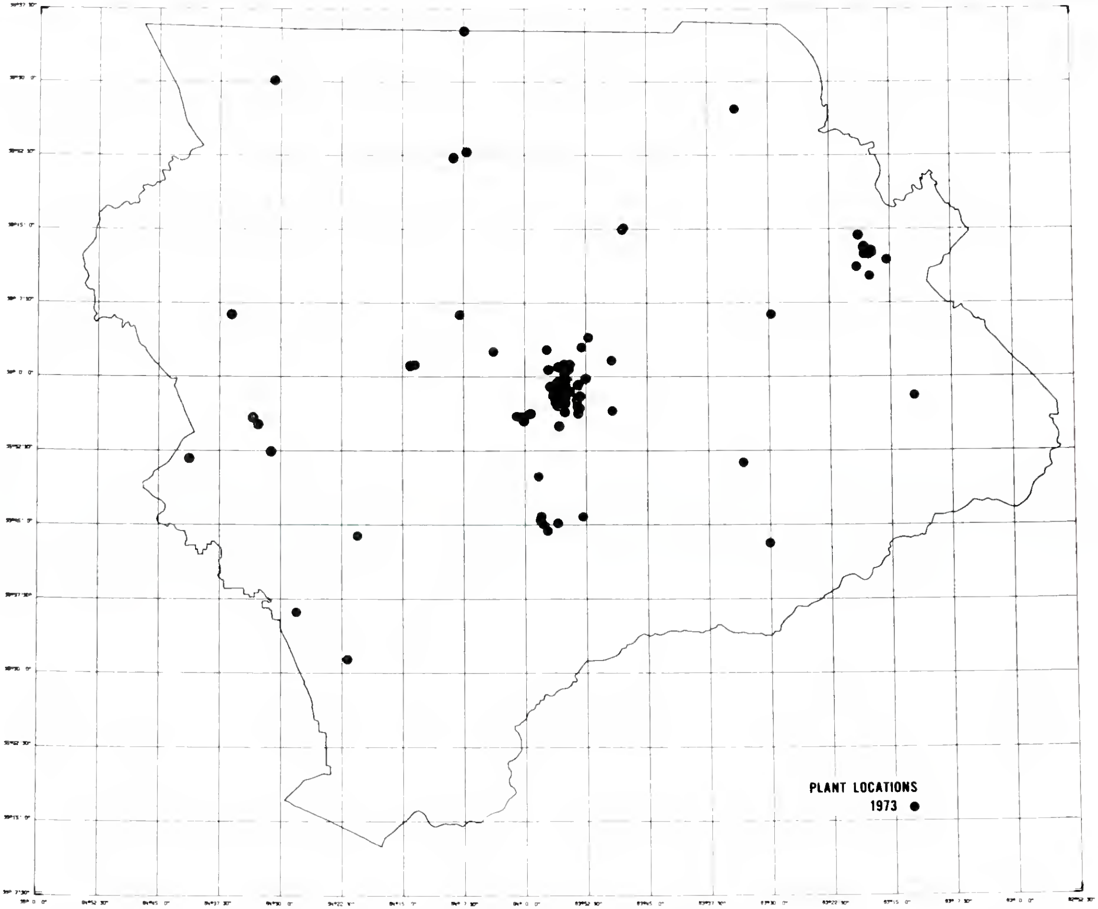
SIC 26 - PAPER AND PULP PRODUCTS
Figure 24.



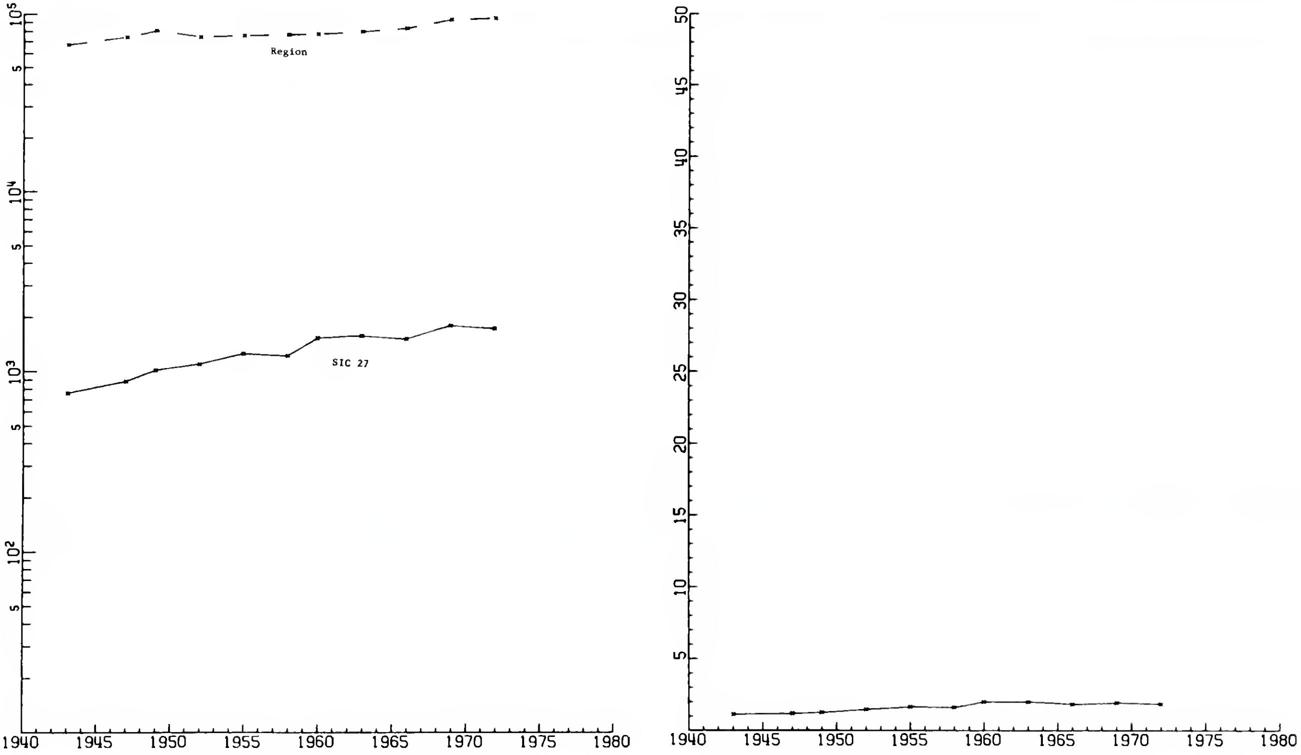
EMPLOYMENT IN SIC 26 AND IN
TOTAL REGIONAL MANUFACTURING

SIC 26's SHARE OF REGIONAL
MANUFACTURING EMPLOYMENT (PERCENT)

SIC 26 - PAPER AND PULP PRODUCTS
Figure 25.



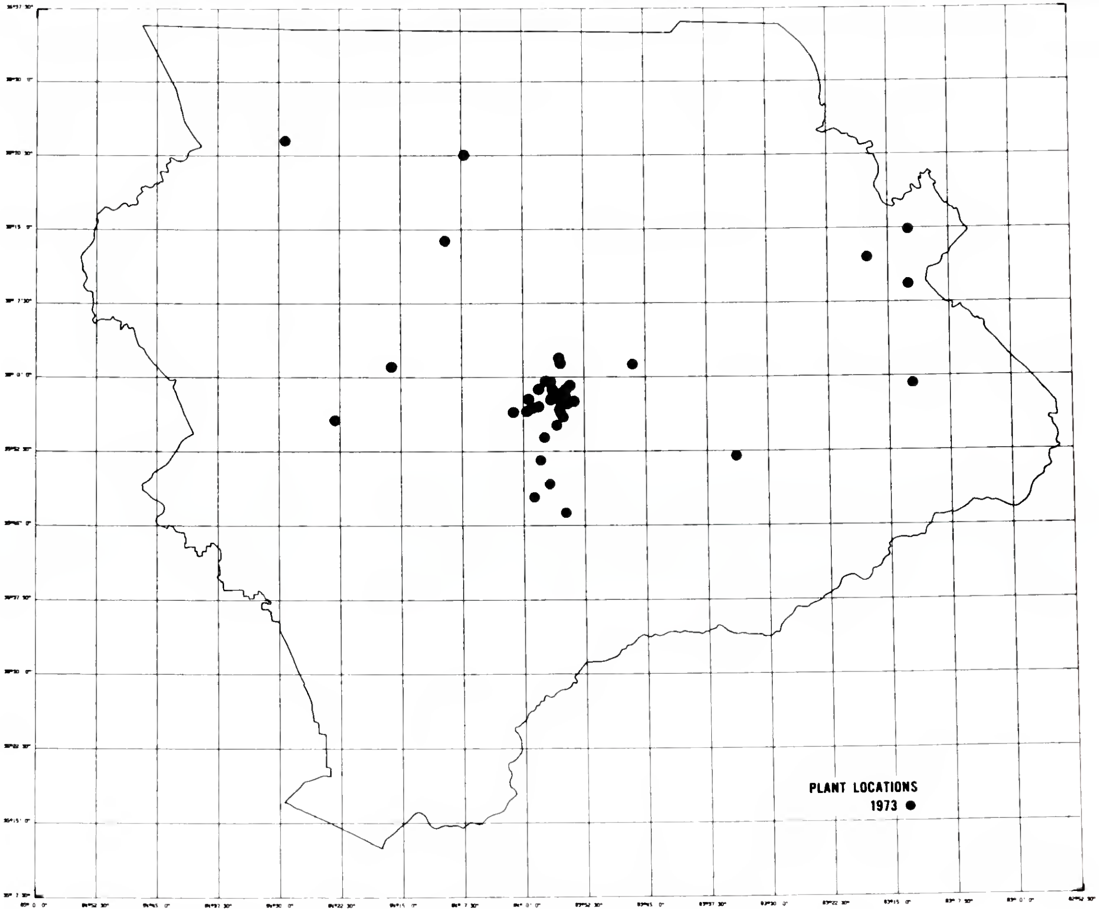
SIC 27 - PRINTING AND PUBLISHING
Figure 26.



EMPLOYMENT IN SIC 27 AND IN
TOTAL REGIONAL MANUFACTURING

SIC 27's SHARE OF REGIONAL
MANUFACTURING EMPLOYMENT (PERCENT)

SIC 27 - PRINTING AND PUBLISHING
Figure 27.



SIC 28 - CHEMICAL PRODUCTS
Figure 28.

relatively small (the largest has 69 employees) while the ENKA plant located at Lowland (six miles south of Morristown) employees over 4500 persons. Large employment figures in Oak Ridge and Morristown (Lowland) skew the average to 308 persons per plant; therefore, the median - 10 per plant - is more descriptive of the true employment picture. Employment in the chemical industry has been erratic in the last two decades (Figure 29) and future expansion is difficult to predict.

Petroleum refining and paving and roofing products (SIC 29)

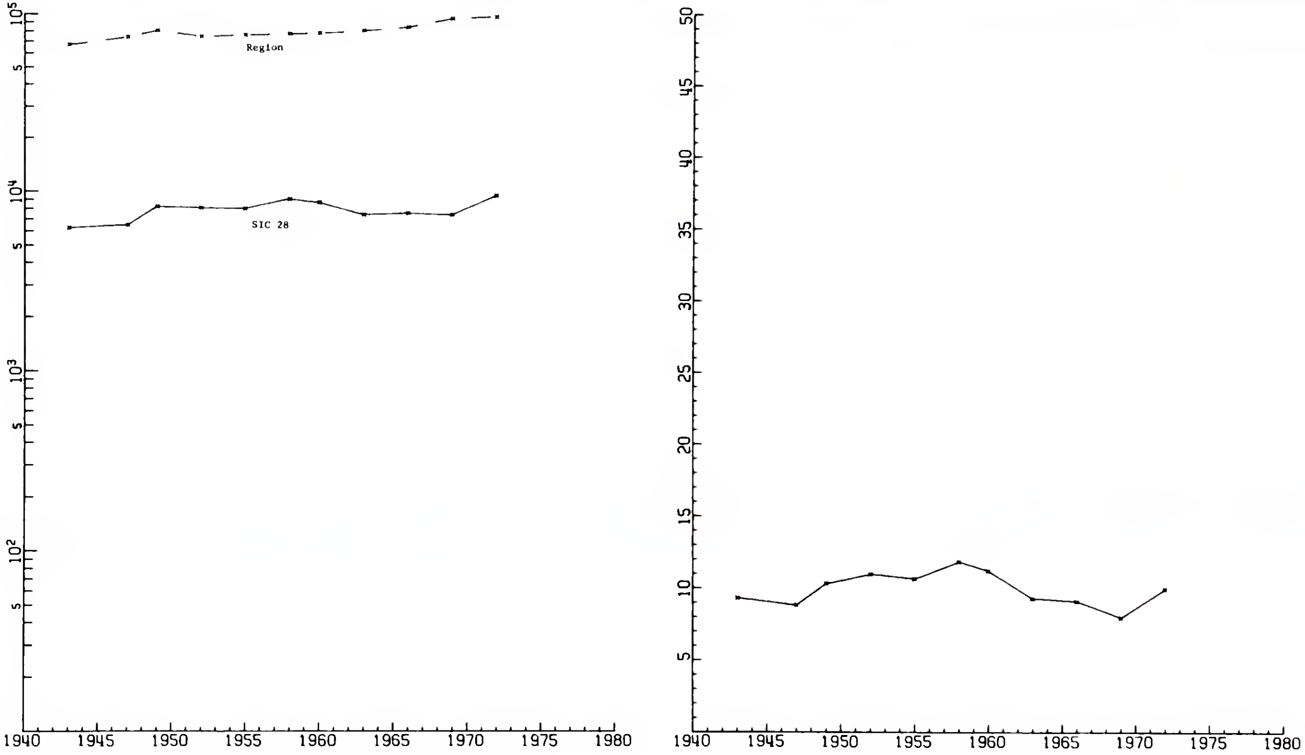
Employment and plant number are relatively insignificant relative to total industry within the region with all but one plant (seven employees) located in Knoxville (Figure 30). Little change in employment has been noted in recent years (Figure 31).

Rubber and plastic products industries (SIC 30)

Ten of the 12 rubber and plastic products industries are found in Knoxville presenting over 60 percent of the employment (Figure 32). The average number of employees is 68 people with 20 employees as the median. Between 1952 and 1973, the new industry growth rate has averaged 16.5 percent but the total employment in 1952 was only 514 persons (Figure 33).

Leather products industries (SIC 31)

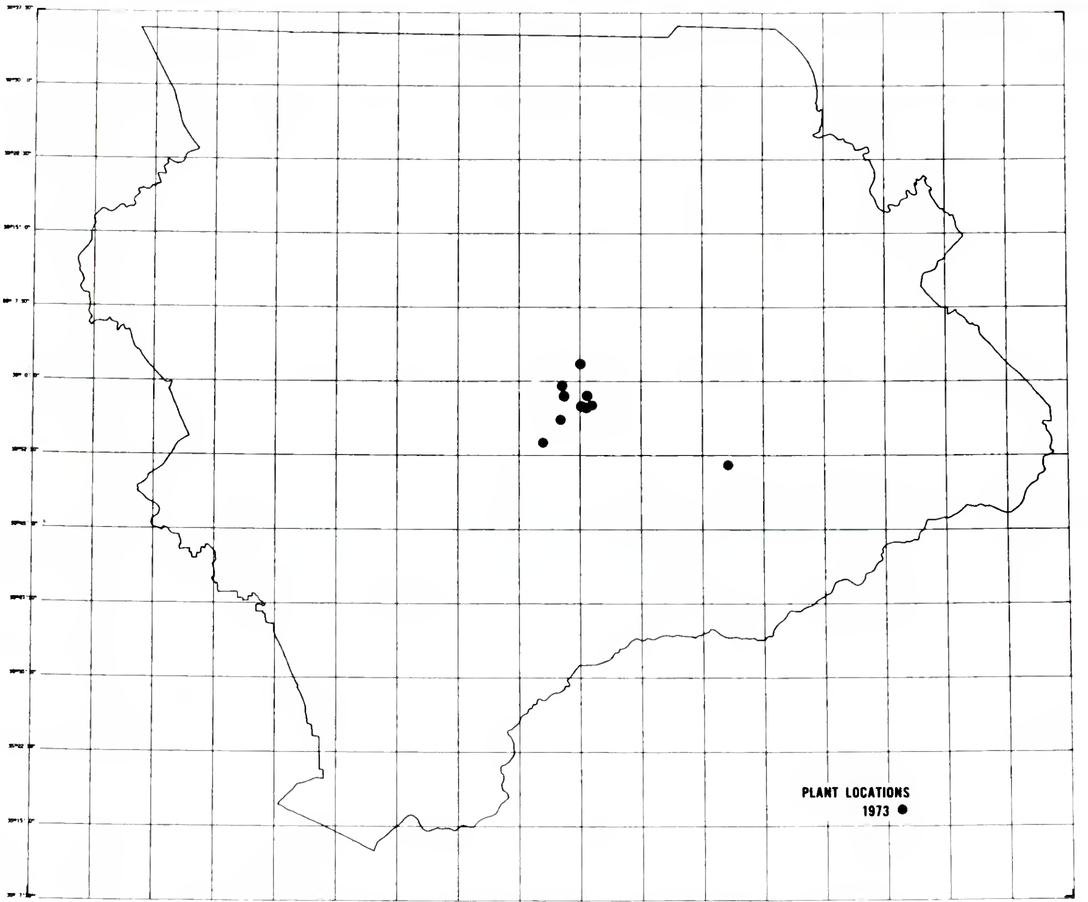
The leather product industries are few in number (15), most occurring in Knoxville, Dandridge (near Jefferson City), and Morristown (Figure 34). The average expansion rate has been significant, 24.6 percent even though the base year employment (1952) was only 546



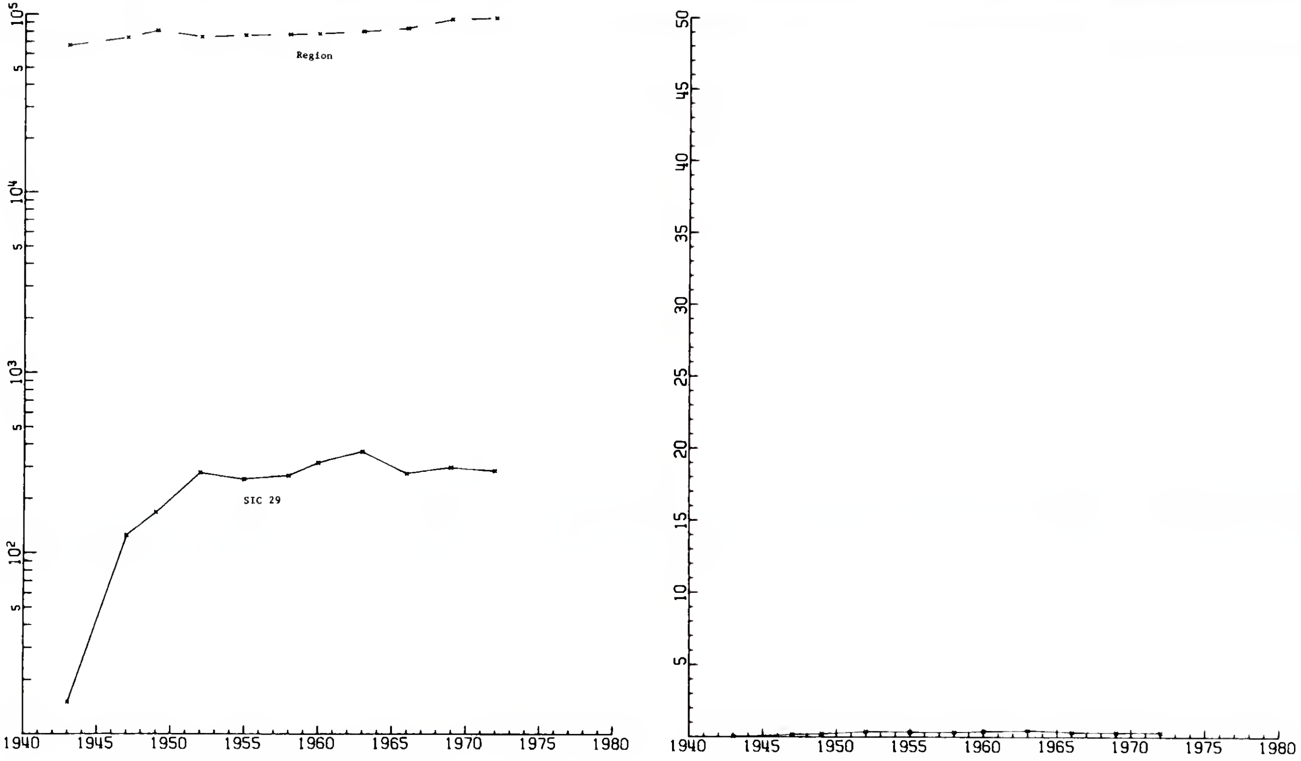
EMPLOYMENT IN SIC 28 AND IN
TOTAL REGIONAL MANUFACTURING

SIC 28's SHARE OF REGIONAL
MANUFACTURING EMPLOYMENT (PERCENT)

SIC 28 - CHEMICAL PRODUCTS
Figure 29.



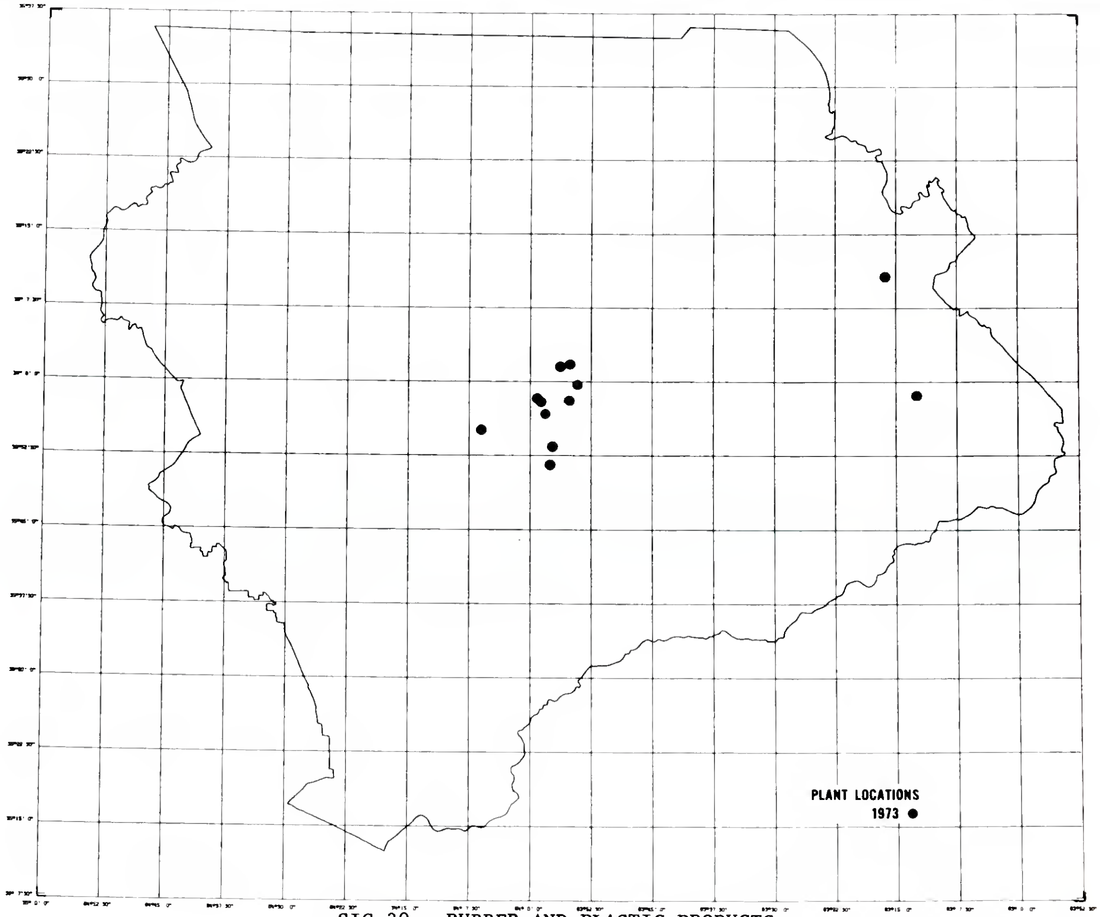
SIC 29 - PETROLEUM REFINING AND PAVING AND ROOFING PRODUCTS
Figure 30.



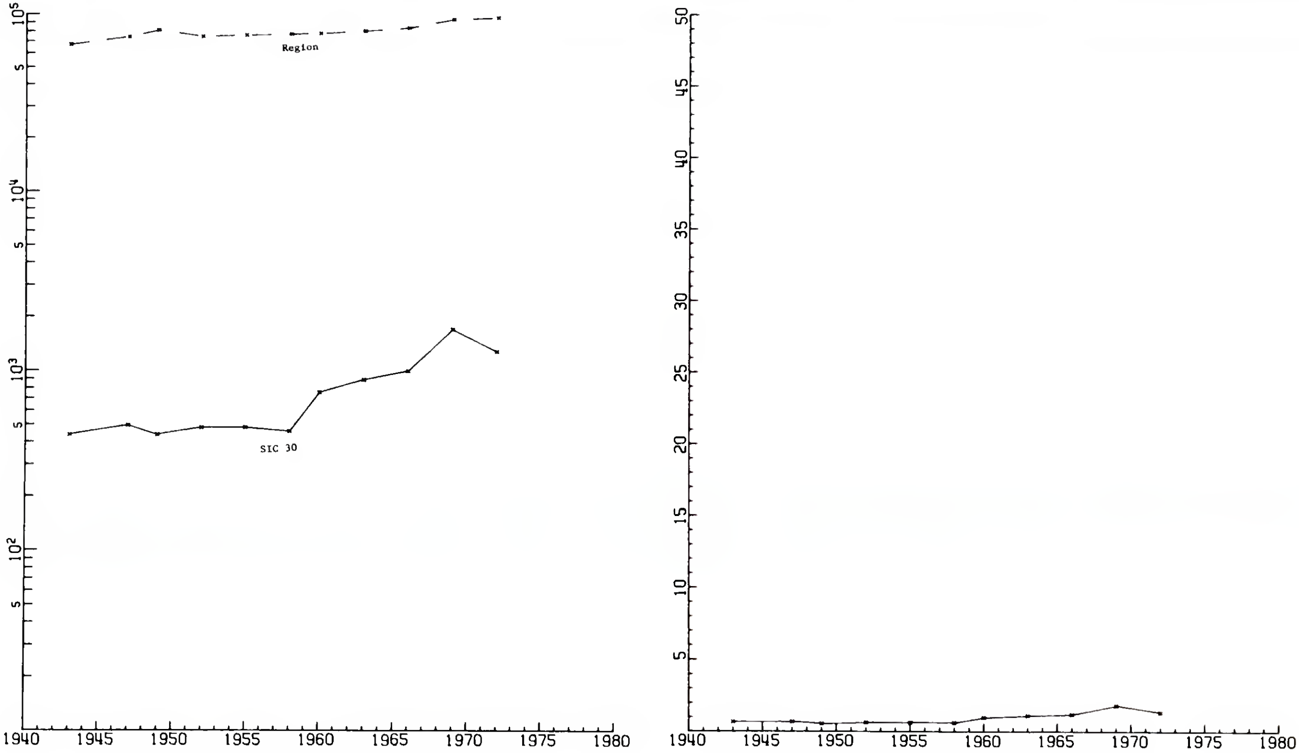
EMPLOYMENT IN SIC 29 AND IN
TOTAL REGIONAL MANUFACTURING

SIC 29's SHARE OF REGIONAL
MANUFACTURING EMPLOYMENT (PERCENT)

SIC 29 - PETROLEUM REFINING AND PAVING
AND ROOFING PRODUCTS
Figure 31.



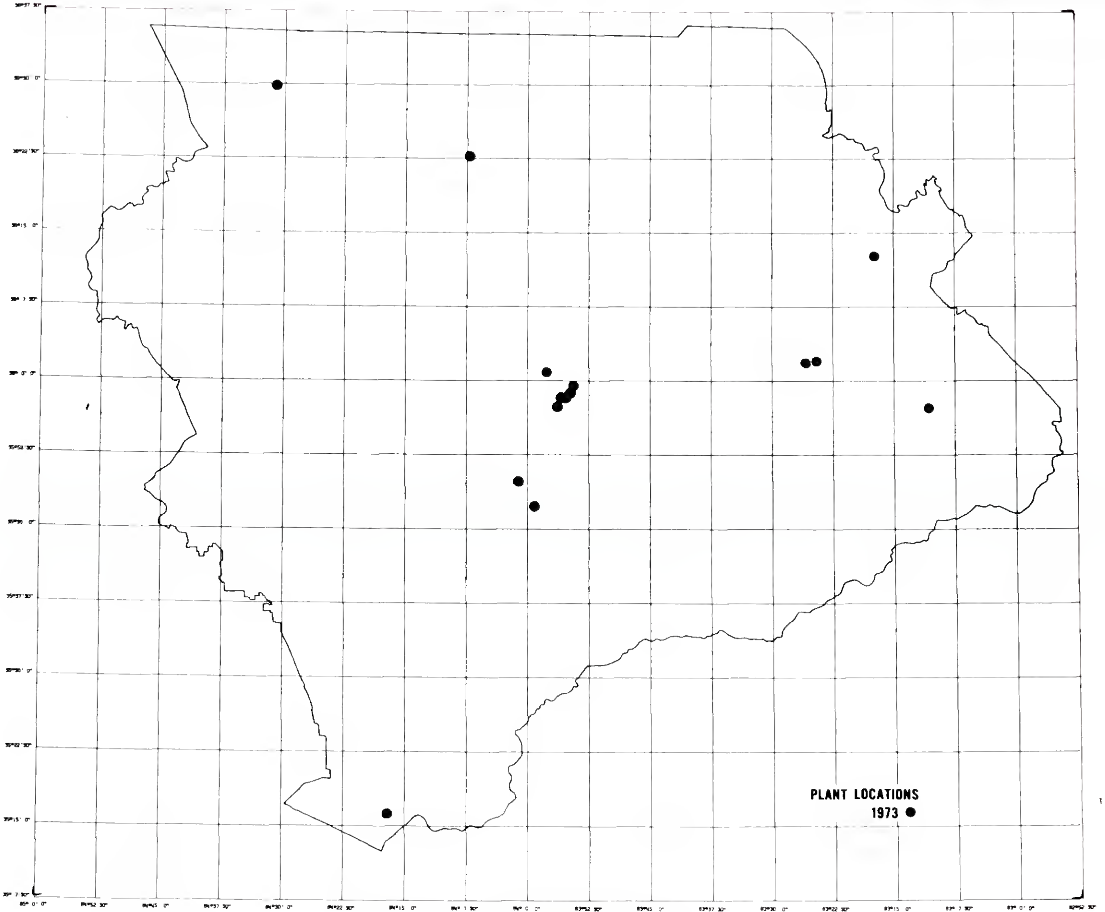
SIC 30 - RUBBER AND PLASTIC PRODUCTS
Figure 32.



EMPLOYMENT IN SIC 30 AND IN
TOTAL REGIONAL MANUFACTURING

SIC 30's SHARE OF REGIONAL
MANUFACTURING EMPLOYMENT (PERCENT)

SIC 30 - RUBBER AND PLASTIC PRODUCTS
Figure 33.



SIC 31 - LEATHER PRODUCTS
Figure 34.

persons. Employment per plant averages 100 persons as does the median, indicating a fairly symmetrical distribution. Expansion in the future may be expected to continue but probably not at such a high rate (Figure 35).

Stone, clay, and glass products industries (SIC 32)

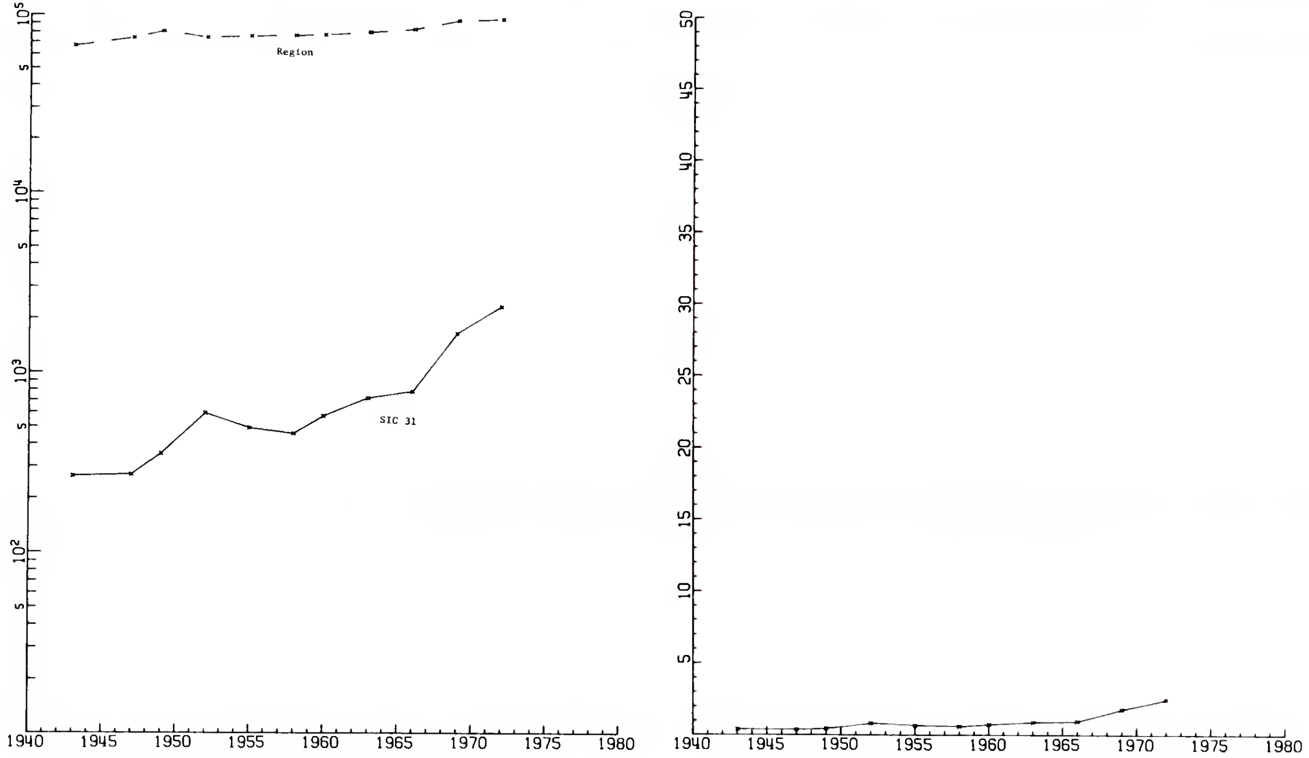
These represent strong local raw material, local market industries, and thus their location is determined by the chance occurrence of resources and the distribution of urban places. The spatial pattern supports this observation (Figure 36). The greatest concentration, as expected, is in the Knoxville vicinity with 2/3 of the total number of plants (68). The average employment per plant is 32 persons. The median is 14 employees per plant. Expansion has kept pace with population growth in recent years and probably will continue to expand in response to total regional growth (Figure 37).

Primary metal industries (SIC 33)

This industry type is distributed throughout the region simply because of the large number of foundries which historically developed in East Tennessee (Figure 38). The largest employment industry is Alcoa Aluminum in Maryville-Alcoa with 5000 employees (70 percent of the total employment). Median employment, however, is only 50 persons per plant. Employment has dropped steadily since 1963 but is expected to level out in the future (Figure 39).

Fabricated metal products industries (SIC 34)

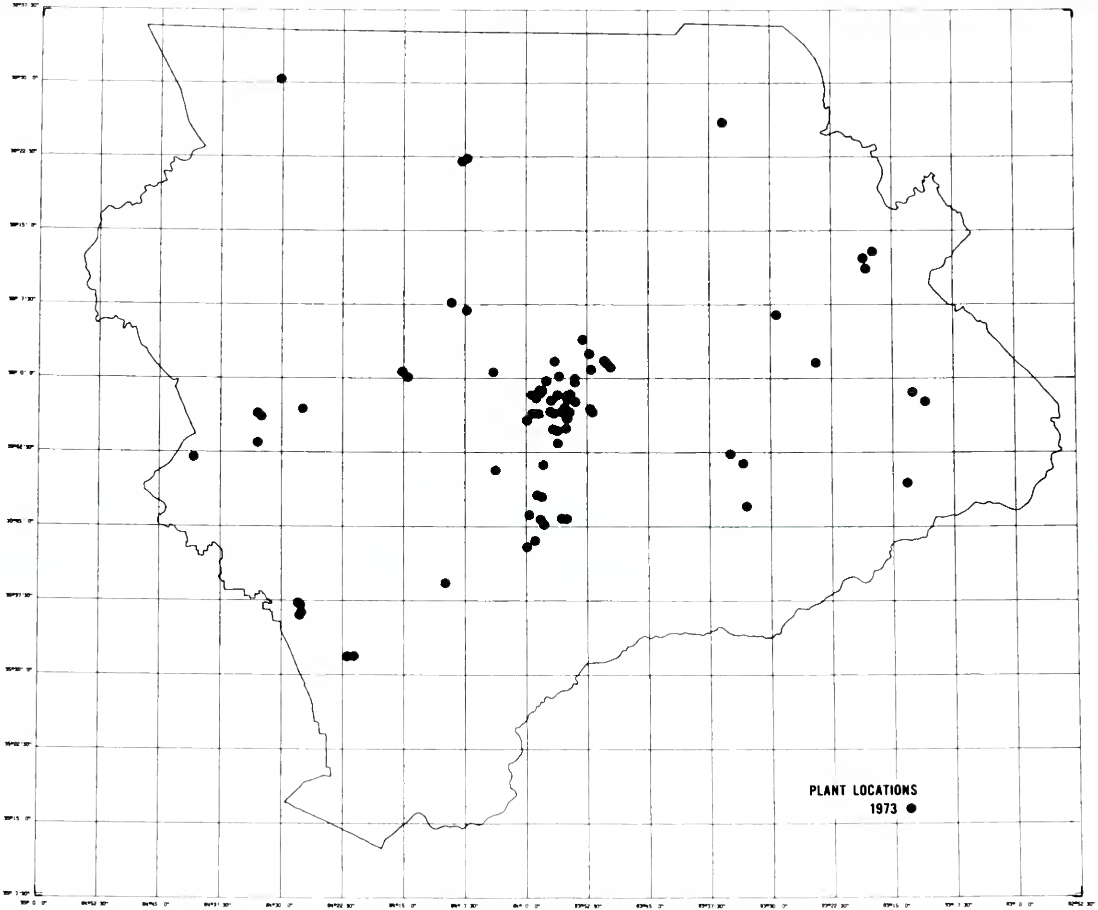
This classification includes welding and machine tool industries which usually develop locally and are local-market oriented. This



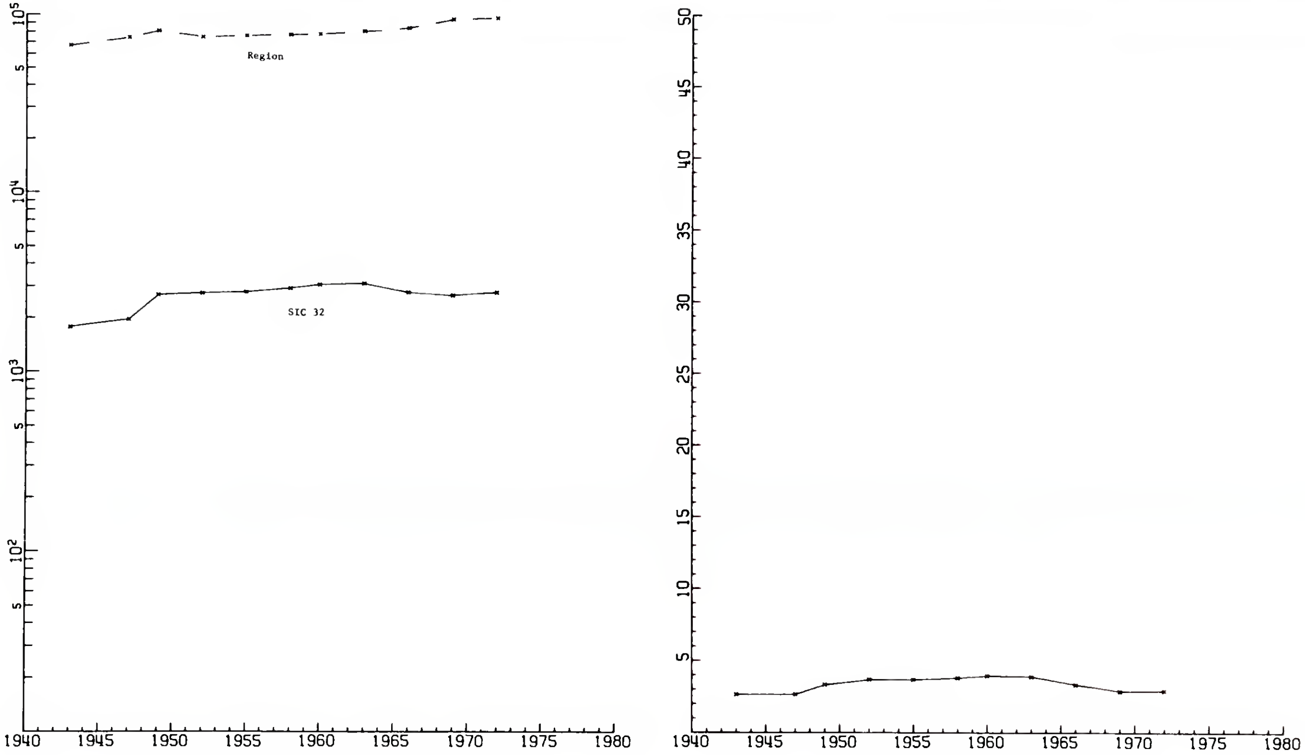
EMPLOYMENT IN SIC 31 AND IN
TOTAL REGIONAL MANUFACTURING

SIC 31's SHARE OF REGIONAL
MANUFACTURING EMPLOYMENT (PERCENT)

SIC 31 - LEATHER PRODUCTS
Figure 35.



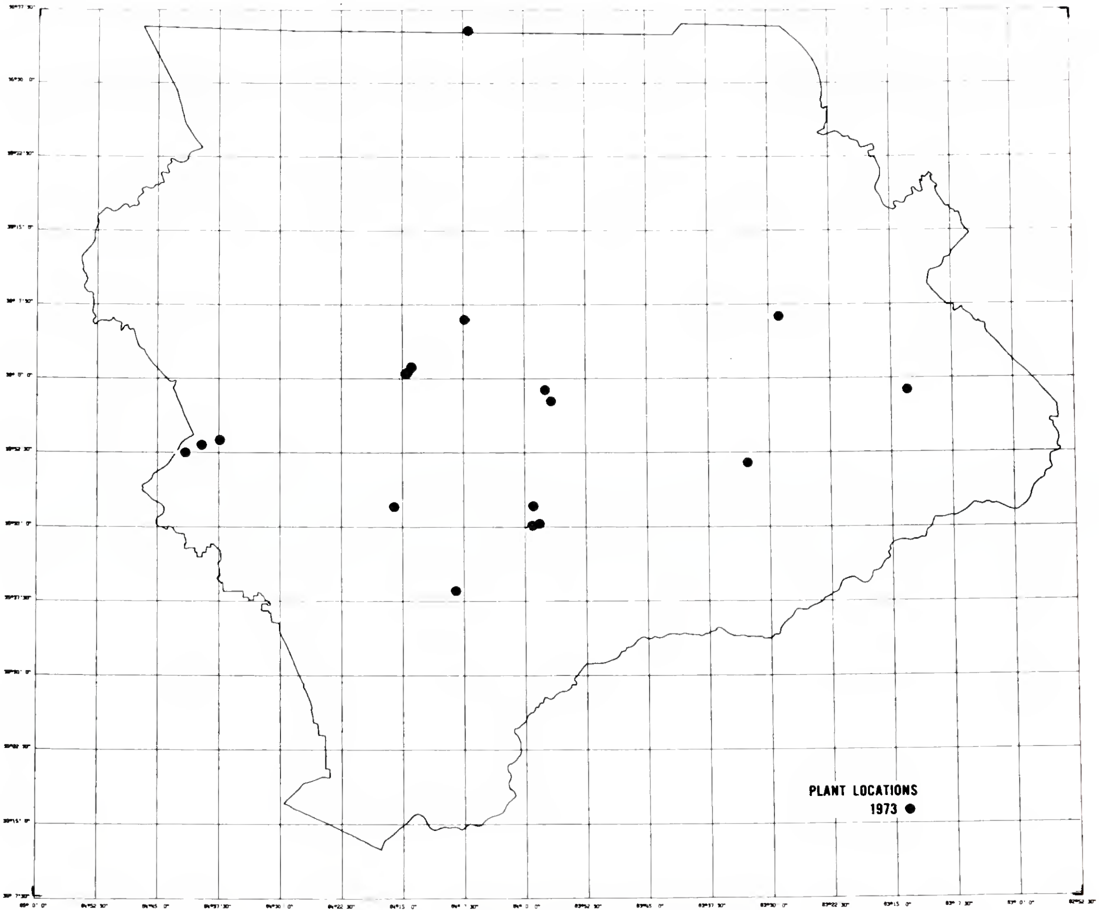
SIC 32 - STONE, CLAY, AND GLASS PRODUCTS
Figure 36.



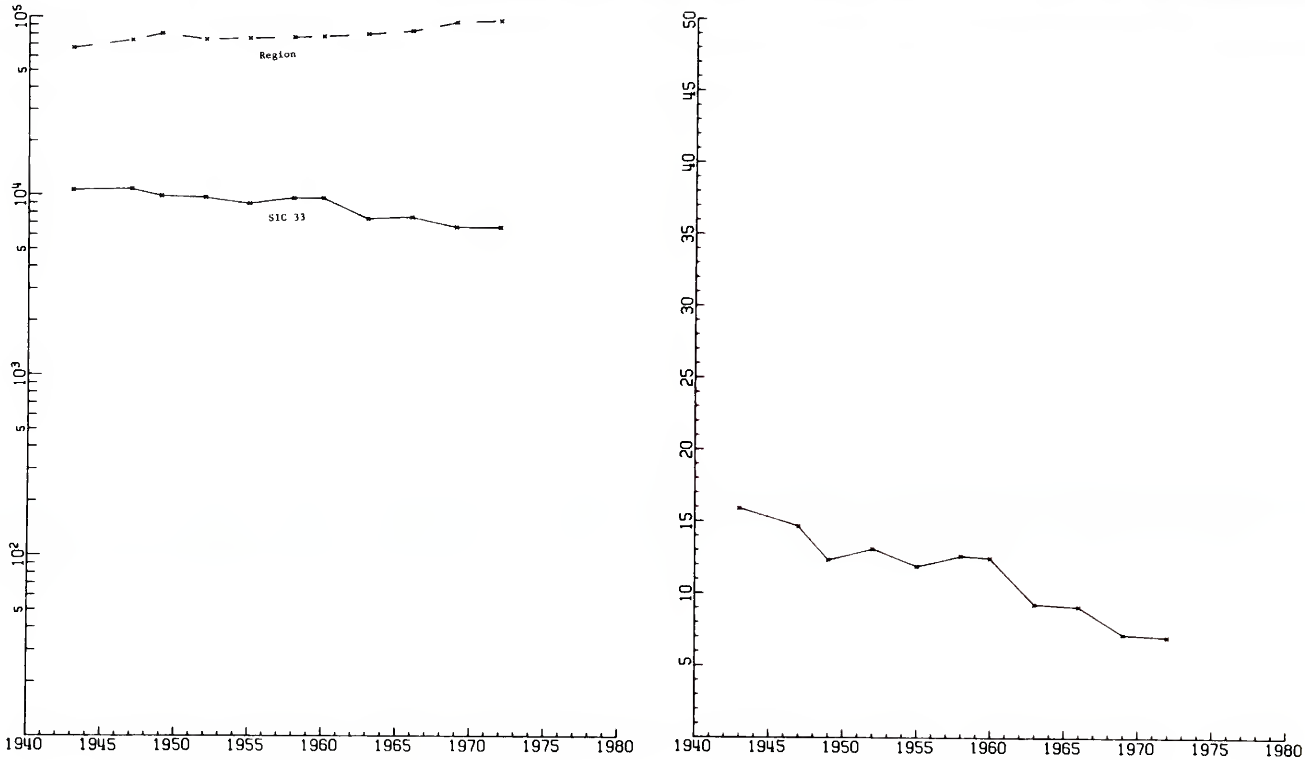
EMPLOYMENT IN SIC 32 AND IN
TOTAL REGIONAL MANUFACTURING

SIC 32's SHARE OF REGIONAL
MANUFACTURING EMPLOYMENT (PERCENT)

SIC 32 - STONE, CLAY, AND GLASS PRODUCTS
Figure 37.



SIC 33 - PRIMARY METAL INDUSTRIES
Figure 38.



EMPLOYMENT IN SIC 33 AND IN
TOTAL REGIONAL MANUFACTURING

SIC 33's SHARE OF REGIONAL
MANUFACTURING EMPLOYMENT (PERCENT)

SIC 33 - PRIMARY METAL INDUSTRIES
Figure 39.

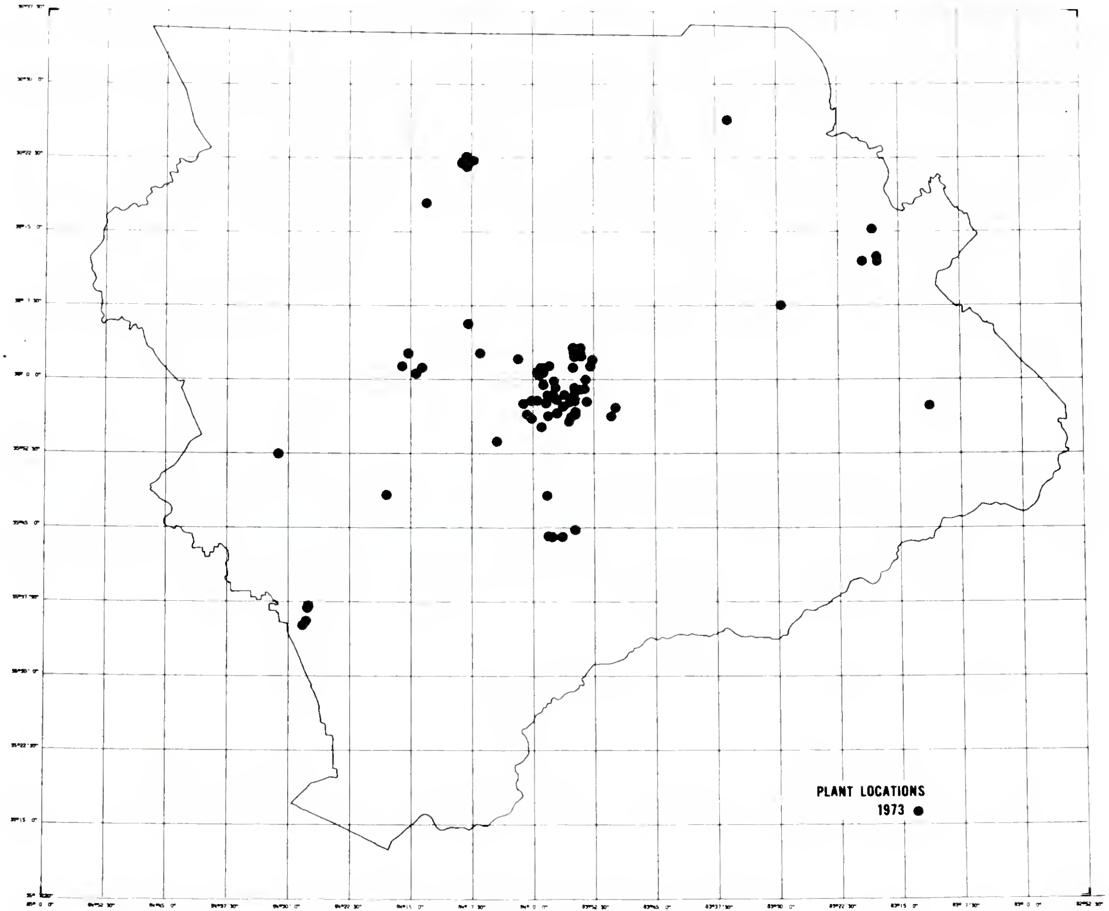
explains the wide distribution of the industry (Figure 40). Most of the 73 plants are found in Knoxville (approximately 75 percent) indicating some response to raw material availability which is greater in the Knoxville area. The average number of persons employed is 45 but the median is only 14 employees per plant. The industry has grown significantly between 1952 and 1973 probably in response to national growth in the transportation and recreational vehicle markets (Figure 41).

Machinery (except electrical) industries (SIC 35)

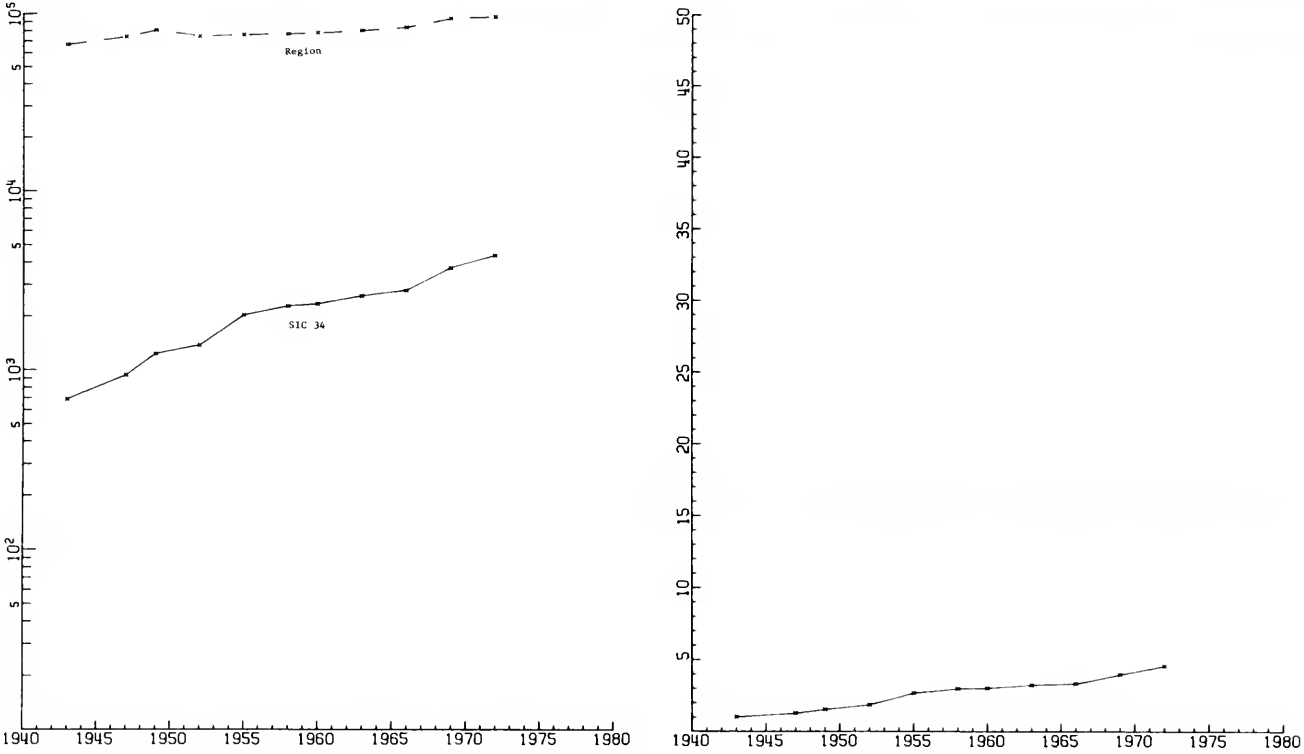
The machinery industry is heavily concentrated in the Knoxville region and to a lesser extent in Oak Ridge and Morristown (Figure 42). Many of these industries perform supporting functions such as the refurbishing of industrial tools (for example, the woodworking tool industries in Morristown). The largest employer has 639 employees but the average for the region is 27 persons per plant and the median is only 7 persons per plant. Total employment has remained fairly constant in the last decade (Figure 43).

Electrical machinery, equipment, and supplies industries (SIC 36)

The electrical machinery industry has grown from 578 employees in 1952 to 2726 employees in 1973, averaging a growth rate of 60.9 percent. The largest employer is Magnavox in Morristown with 716 employees in 1970. Average employment is 120 persons; the median is 40 persons per plant. Most of the industry is concentrated in Knoxville and dispersed lightly elsewhere (Figure 44). In recent years, employment has expanded significantly (Figure 45).



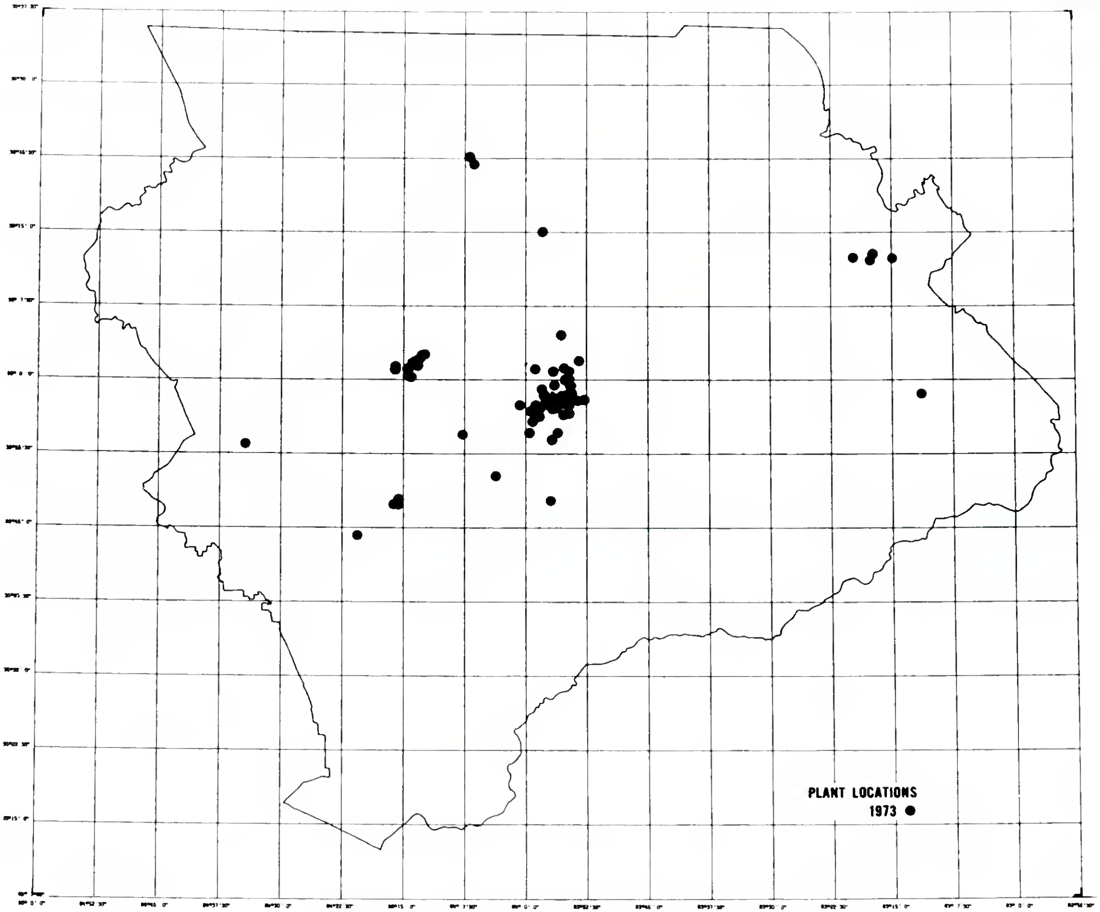
SIC 34 - FABRICATED METAL PRODUCTS
Figure 40.



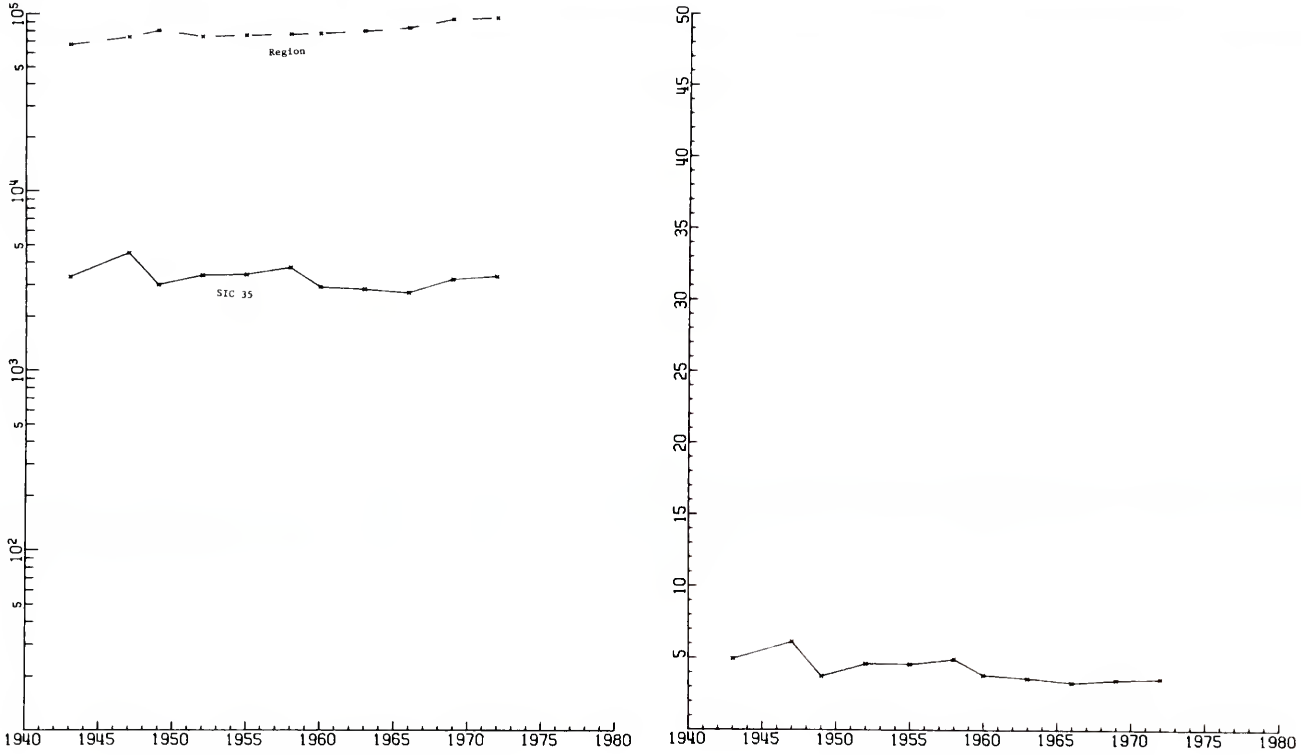
EMPLOYMENT IN SIC 34 AND IN
TOTAL REGIONAL MANUFACTURING

SIC 34's SHARE OF REGIONAL
MANUFACTURING EMPLOYMENT (PERCENT)

SIC 34 - FABRICATED METAL PRODUCTS
Figure 41.



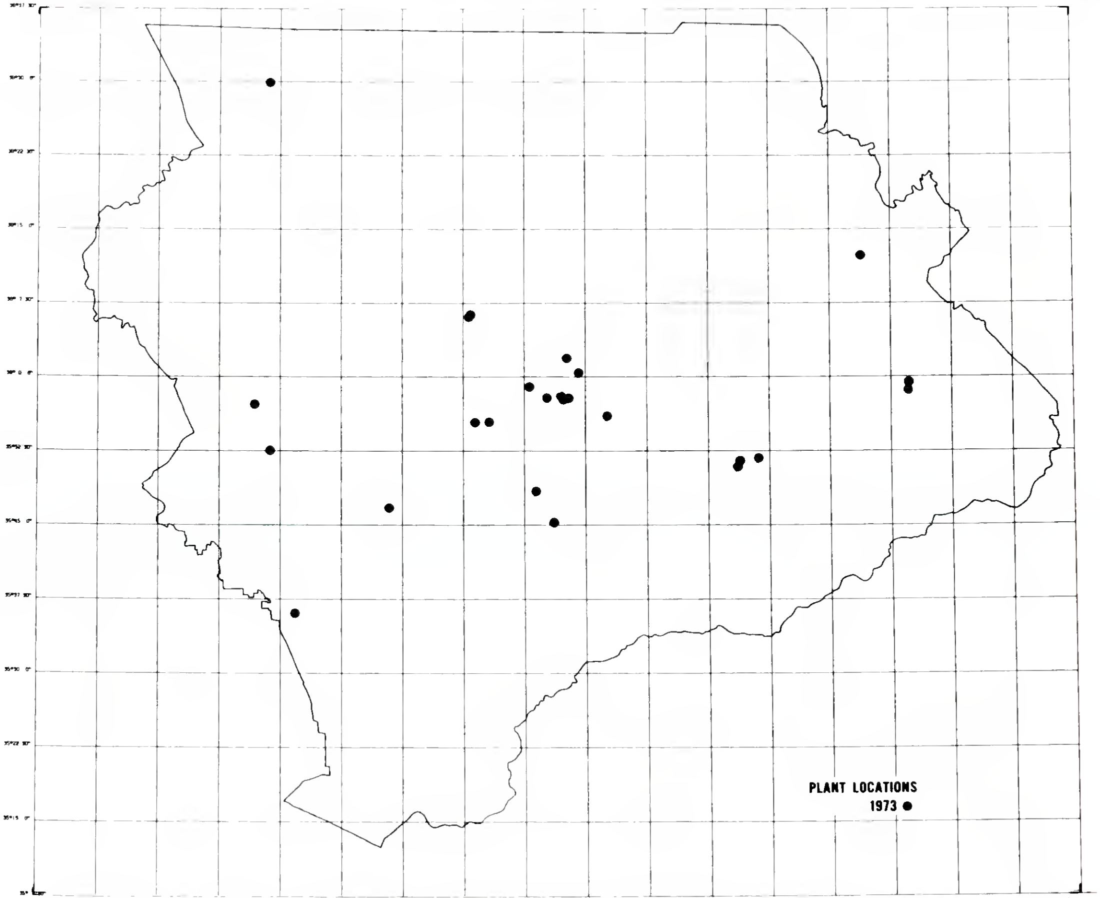
SIC 35 - MACHINERY (EXCEPT ELECTRICAL)
Figure 42.



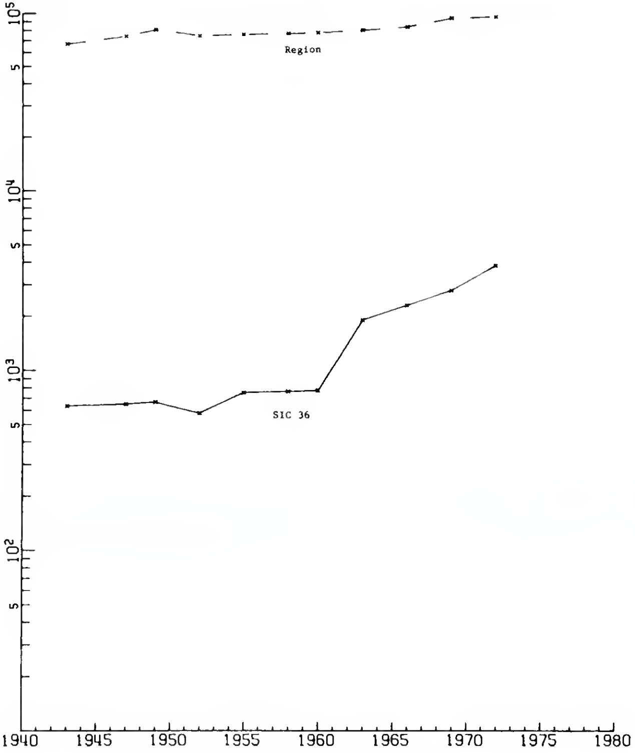
EMPLOYMENT IN SIC 35 AND IN
TOTAL REGIONAL MANUFACTURING

SIC 35's SHARE OF REGIONAL
MANUFACTURING EMPLOYMENT (PERCENT)

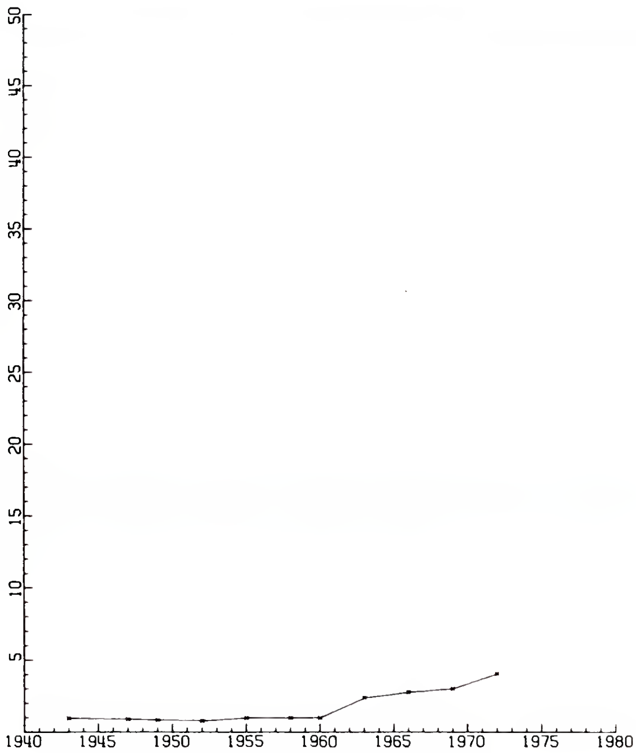
SIC 35 - MACHINERY (EXCEPT ELECTRICAL)
Figure 43.



SIC 36 - ELECTRICAL MACHINERY, EQUIPMENT, AND SUPPLIES
Figure 44.



EMPLOYMENT IN SIC 36 AND IN
TOTAL REGIONAL MANUFACTURING



SIC 36's SHARE OF REGIONAL
MANUFACTURING EMPLOYMENT (PERCENT)

SIC 36 - ELECTRICAL MACHINERY, EQUIPMENT,
AND SUPPLIES
Figure 45.

Transportation equipment industries (SIC 37)

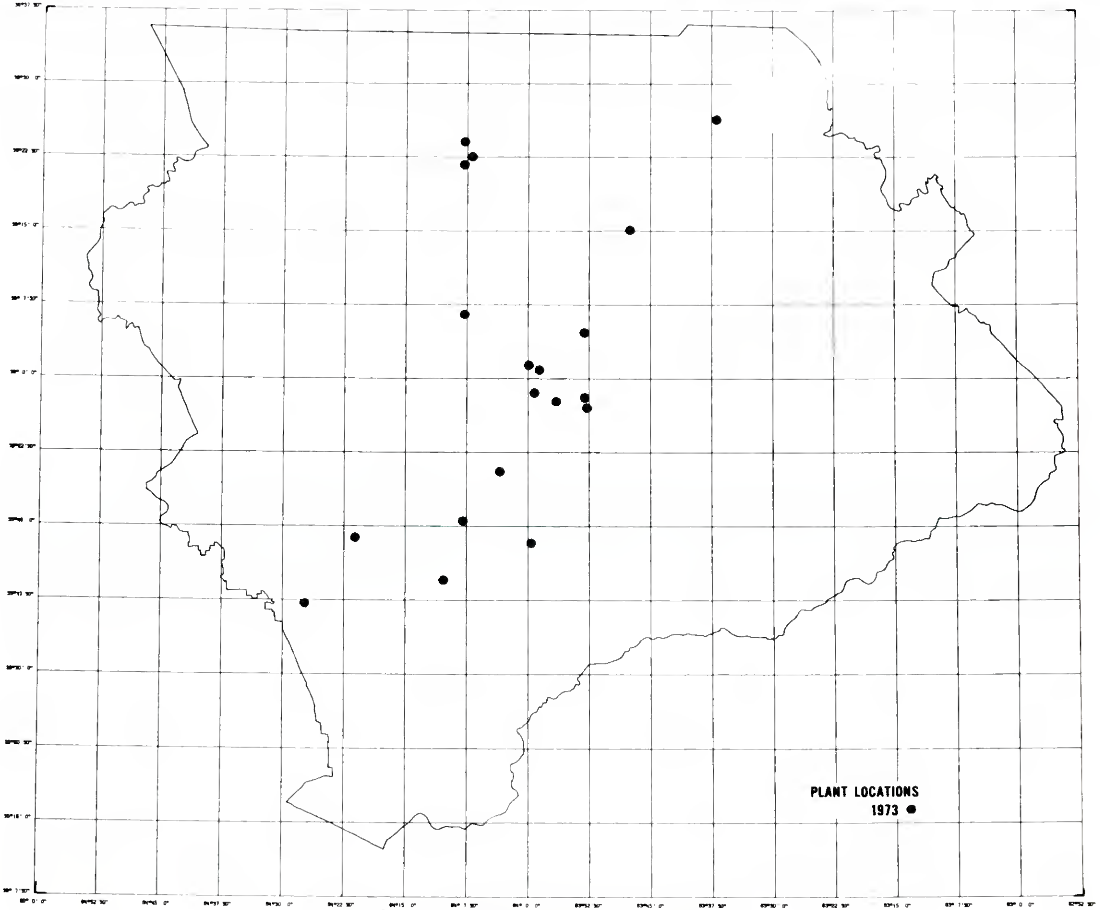
A large portion of the transportation industry is found in Knoxville; however, several trailer, travel trailer, and truck camper manufacturers are found near New Tazewell, Sweetwater, and LaFollette (Figure 46). Total employment is low (413 employees) with the average plant employing 34 persons. The median is 15 persons. Because of the low initial employment in 1952 (106 people) the growth rate seems phenomenal (85.4 percent). Regionally, however, the industry is of minor importance when compared to total employment except in the smaller communities (Figure 47). Recent problems with transportation fuel availability may dampen future growth in this industry.

Instrument and related products industries (SIC 38)

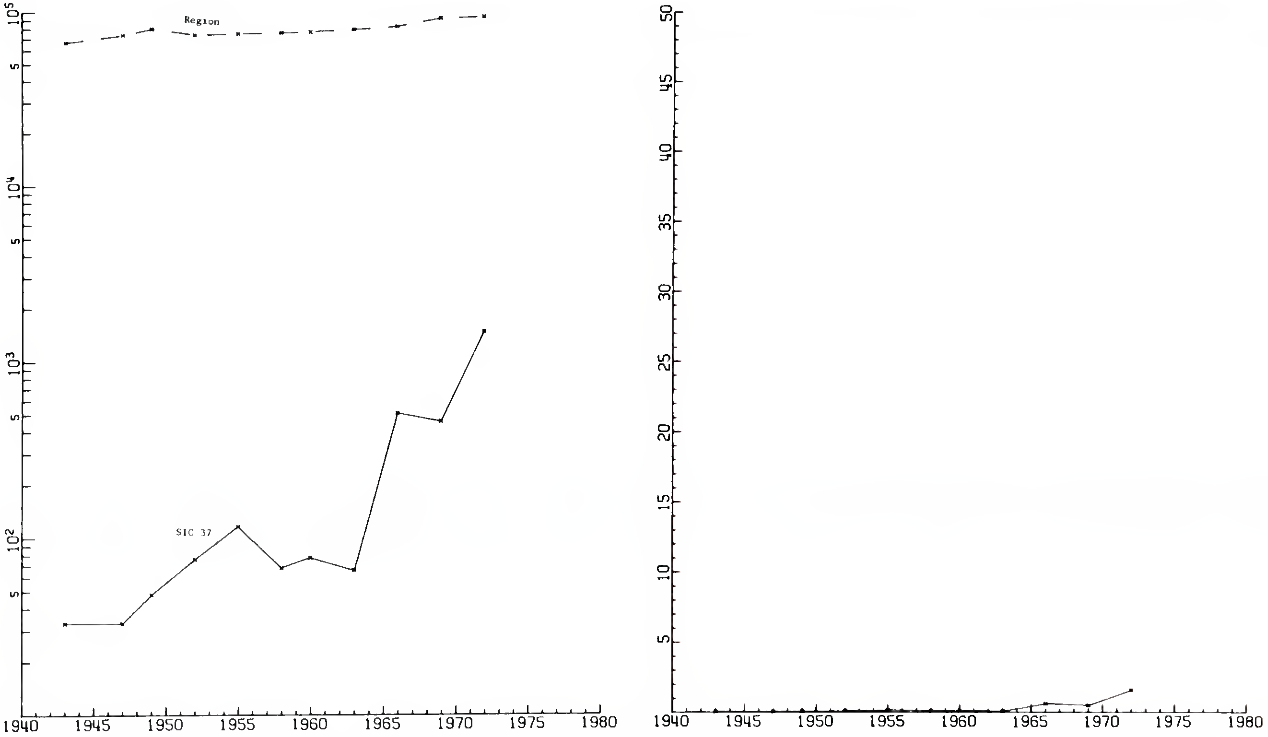
These industries are concentrated mostly in Knoxville and Oak Ridge (Figure 48). Oak Ridge AEC plants distort the picture considerably with over 10,000 employees. Excluding Oak Ridge the average employment is 93 persons per plant while the median employment is only 10 persons. Little expansion in employment has occurred in recent years (Figure 49).

Miscellaneous industries (SIC 39)

Almost all miscellaneous industries are located in Knoxville, with 48 of the 54 plants in the region (Figure 50). Average employment is 44 persons, with the median 10 persons per plant. Among the more significant industries are National Cash Register in Morristown and Southern Athletic Inc. in Knoxville with 300 and 780 employees respectively. Changes in employment have not been significant in recent years although growth is evident (Figure 51).



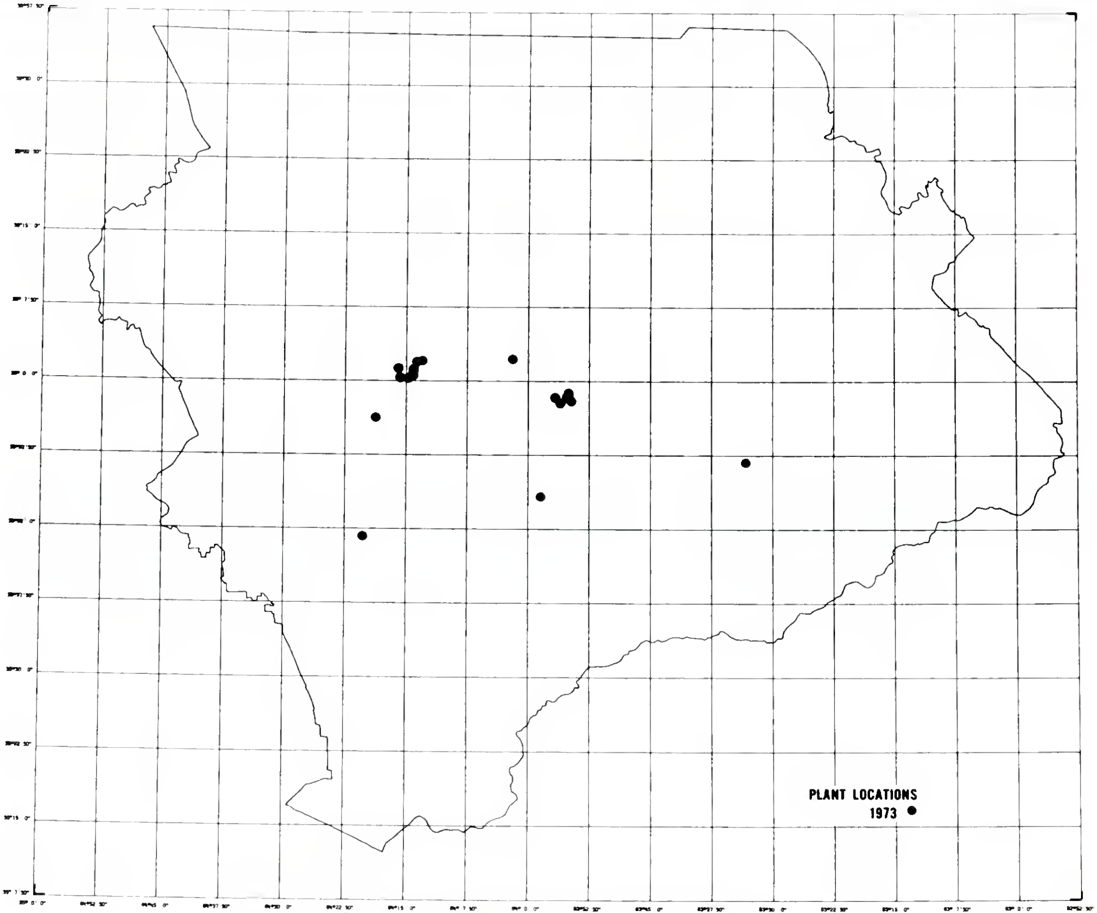
SIC 37 - TRANSPORTATION EQUIPMENT
Figure 46.



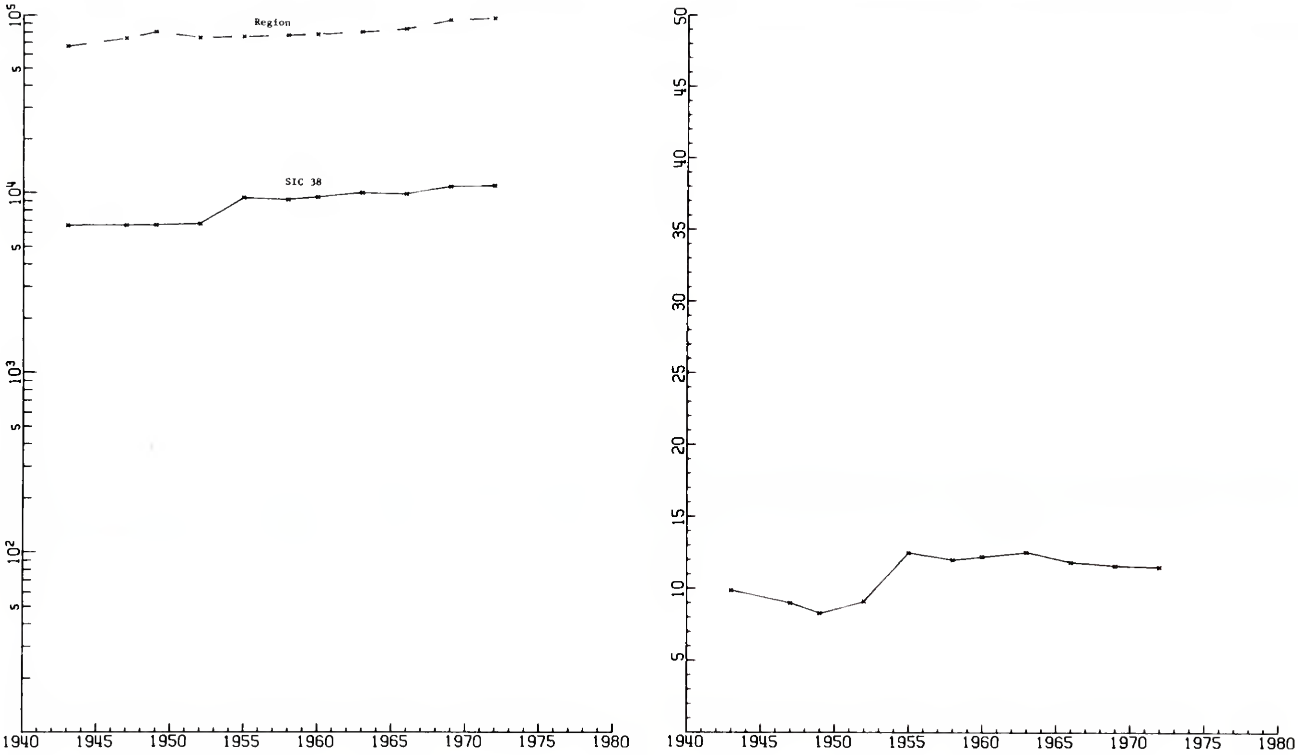
EMPLOYMENT IN SIC 37 AND IN
TOTAL REGIONAL MANUFACTURING

SIC 37's SHARE OF REGIONAL
MANUFACTURING EMPLOYMENT (PERCENT)

SIC 37 - TRANSPORTATION EQUIPMENT
Figure 47.



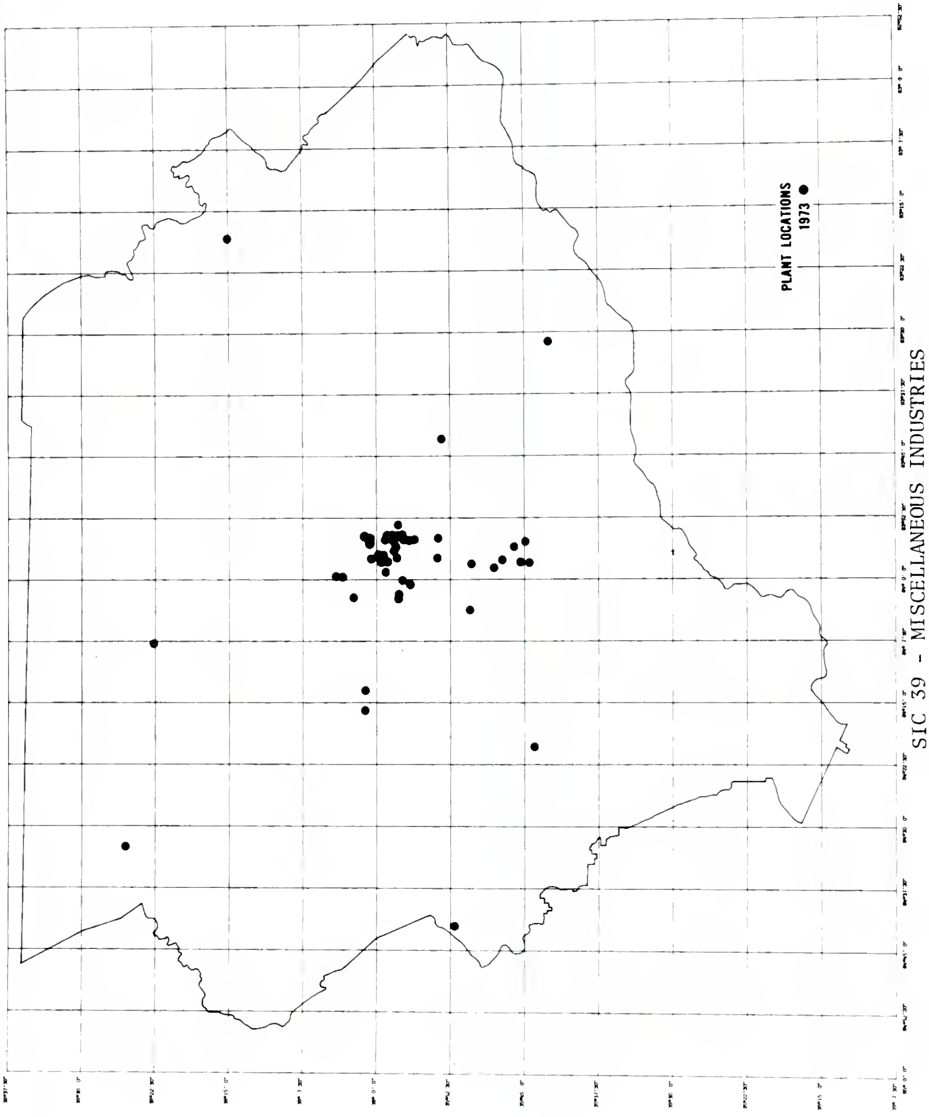
SIC 38 - INSTRUMENTS AND RELATED PRODUCTS
Figure 48.



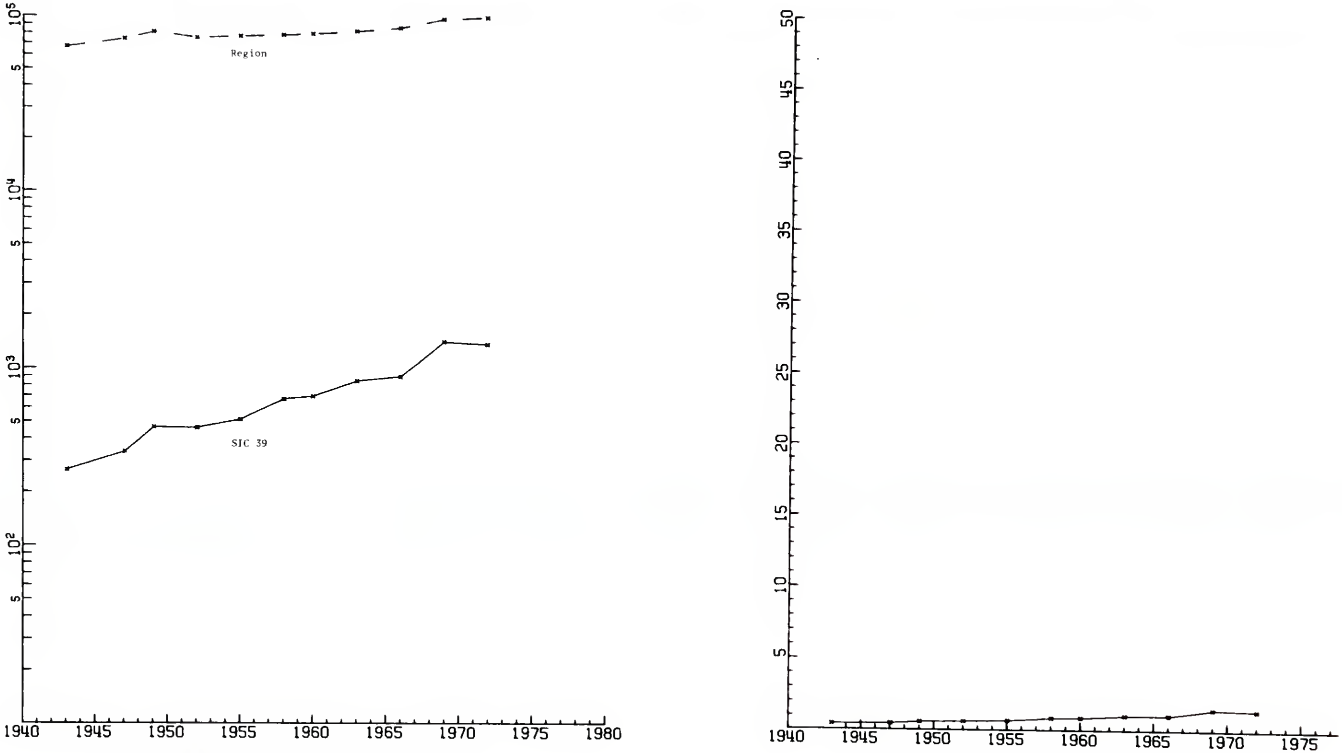
EMPLOYMENT IN SIC 38 AND IN
TOTAL REGIONAL MANUFACTURING

SIC 38's SHARE OF REGIONAL
MANUFACTURING EMPLOYMENT (PERCENT)

SIC 38 - INSTRUMENTS AND RELATED PRODUCTS
Figure 49.



SIC 39 - MISCELLANEOUS INDUSTRIES
Figure 50.



EMPLOYMENT IN SIC 39 AND IN
TOTAL REGIONAL MANUFACTURING

SIC 39'S SHARE OF REGIONAL
MANUFACTURING EMPLOYMENT (PERCENT)

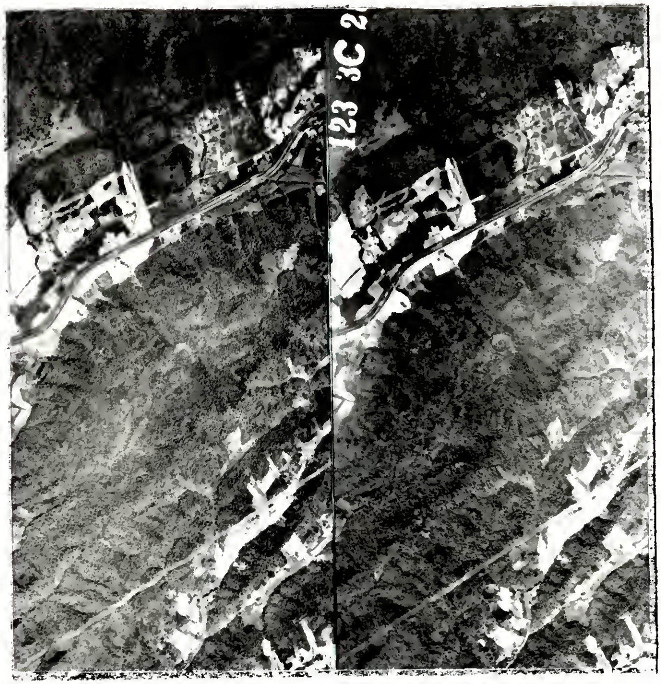
SIC 39 - MISCELLANEOUS INDUSTRIES
Figure 51.

Data Collection

This research effort is unique in the use of historical aerial photography in the analysis of industrial development processes. The use of aerial photography in the analysis of land use change in itself is not unusual; however, its use as an aid to develop a land use model is considered to be novel. Experience indicates that aerial photography provides a convenient and economical means to assess the processes effecting previous land use change and to assess the current potential of various land areas for future development. Remote sensing has proven to be an efficient data acquisition technique capable of partially fulfilling many urban and regional modeling needs.

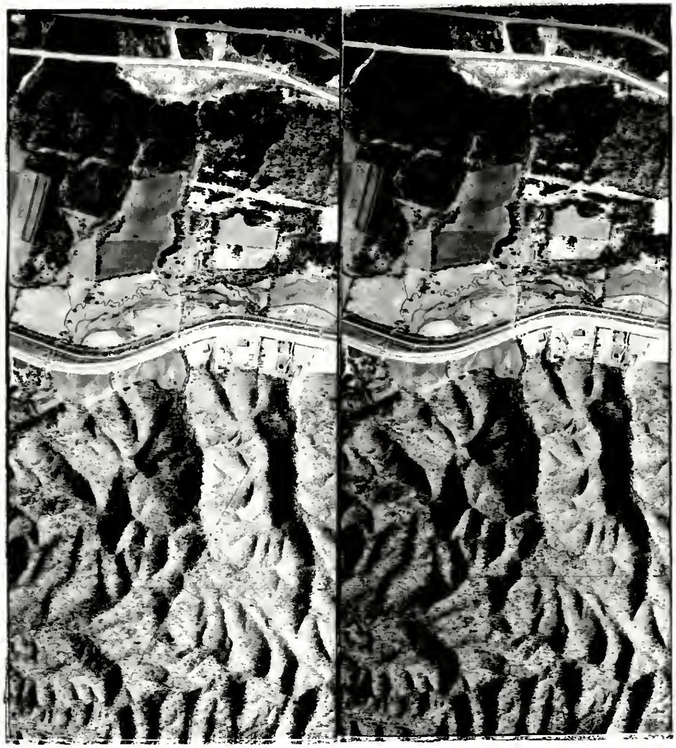
To illustrate the use of the aerial photography in this analysis two stereo images have been included (Figures 52 and 53) illustrating the before and after scenes of an industrial location event. The industry site is located near Harriman, Tennessee. The site was occupied in 1966 by the Beta-Tek Inc. which manufactures electrical machinery. Present employment is approximately 130 people. The first stereo image indicates the condition of the site and surroundings as of March 30, 1958 (TVA photography) while the second stereo image indicates the conditions as of March 22, 1974 (NASA photography).

Aerial photography is utilized in the following manner: The ORNL data base contains information concerning the general location of existing industry within the ETDD region; the date of industry located in the region; the number of employees initially employed and presently employed; and the primary and secondary SIC designation of



1958 - STEREO IMAGE OF BETA-TEK INDUSTRIAL SITE
(TVA - 1:30,000)

Figure 52.



1974 - STEREO IMAGE OF BETA-TEK INDUSTRIAL SITE
(NASA - 1:24,000)

Figure 53.

each industry. Using a CALCOMP plotter these data were spatially plotted at a scale of 1:250,000 for initial analysis. Additional plots at a scale of 1:24,000 were obtained of those TVA-USCS topographic quadrangles having manufacturing plants. Using historical aerial photography, census materials and interviews with local citizens, spatial conditions which existed prior to the time of industrial location event were reconstructed. Location events occurring before 1950 were not analyzed. However, industries which expanded or relocated after 1950 were included. Most of the location events analyzed occurred after 1956, the year Congress passed the National Defense Highway Act creating the Interstate Highway System. It is thought that many of the locational decisions after 1956 (and perhaps before) were partially affected by knowledge of the location of Interstate highways.

It was initially intended to analyze each industrial location event for which data were available. Once data acquisition was begun, it became apparent that analysis of each event would take longer than anticipated. With over 1,000 industries in the ETDD region, it was impossible to complete the analysis in the time allotted. After consultation with several ORNL statisticians, a minimum sample size of 150 industries was considered to be adequate to determine the statistical significance of the variables believed to be associated with industrial site selection processes. (This represents a 15 percent sample of the total number of industries presently within ETDD and a 33 percent sample of the industries which have located in ETDD since 1950.) Industries were selected in a manner to maintain a homogenous mixture and to assure an adequate regional sample. Efforts were also made to maintain a sampling balance between metropolitan and rural industry according to plant distribution.

As mentioned above, additional data sources were utilized in the analysis along with historical aerial photography. Itemized below are some of the data sources utilized in acquiring measures of the variables.

	INDEX		VARIABLE	PRIMARY DATA SOURCES[10]
1.	Site Preparation Cost	a.	Drainage conditions	Soils conditions from ORNL data base; aerial photography; topographic maps; visual inspection
		b.	Slope of Land	
		c.	Vegetation cover	
2.	Market Price of Land	a.	Per acre cost of land	Generalized land rent model; topographic maps; aerial photography; local opinion
3.	Proximity to Suitable Labor Force	a.	Proportion of urban area within 2-1/2 miles of site[11]	Aerial photography; topographic maps
4.	Transportation Accessibility	a.	Distance to major roads, railroads, airports, and waterways	State highway maps; aerial photography

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[10] The acquisition of data was subject to use of the most convenient method of acquisition which in some instances could only be acquired by interview as part of the ORNL data base is incomplete.

[11] The 2-1/2 mile limit was selected partly on the basis of observing historical patterns of industrial location but mostly because of the dimension of the cell to be used in the ORNL simulation model (170 acres).

INDEX	VARIABLE	PRIMARY DATA SOURCES
5. Utilities	a. Kinds and qualities available near site	Local interviews; utility and municipal service maps; topographic maps; aerial photography
6. Compatibility with Existing Land Uses	a. Types of adjacent land use	Local interviews; aerial photography; topographic maps
	b. Types of adjacent zoning	Zoning maps; local interviews
7. Neighborhood or Community Attractiveness and Amenities	a. Condition and density of adjacent land uses	Field observation; local interviews; aerial photography; census data; topographic map
	b. Proximity to hospitals, schools, parks, and churches	Topographic maps; aerial photography; state highway maps; field observation
8. Industrial Park Space	a. Availability of suitable building or land in an existing industrial park	Local planning office; industrial park maps; aerial photography
	b. Quality of park	Field observation; local interviews; aerial photography

In addition to these variables, observations were tabulated for: the position of the site relative to Knoxville to determine if orientation toward Knoxville was important; the existence of a suitable building on the site; and whether the site was located within a cluster of existing industries.

Statistical Procedures

It was expected that as analysis of the determinants of industrial location progressed, insight would be acquired as to the proper methodologies to be employed in rating and evaluating the importance of the variables examined. As the study progressed and the complexities of the industrial site selection process were recognized, it was decided that simple statistical procedures would not be sufficient to "untangle" the interacting variables to produce meaningful answers. Therefore, a multivariate procedure (specifically factor analysis) was chosen to describe interconnection of the variables that appear to be meaningfully related to the industrial site selection process.

There are several reasons for this decision. Among many multivariate procedures, factor analysis is distinguished by its data-reduction capabilities. "Given an array of correlation coefficients for a set of variables, factor-analytic techniques enables us to see whether some underlying pattern of relationships exists such that the data may be 'rearranged' or 'reduced' to a smaller set of factors or components that may be taken as source variables accounting for the observed interrelations in the data."[12] Common applications of the method may be grouped into one of the following categories: "(1) exploratory uses — the exploration and detection of patterning of variables with a view of the discovery of new concepts and a possible reduction of data; (2) confirmatory uses — the testing of hypotheses about the structuring of variables in terms of the expected number of significant factors and factor loadings; and (3) uses as a measuring device -- the construction of indices to be used as new variables in later analysis."[13]

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[12] Norman Nie, Dale H. Bent, and C. Haddie Hull, SPSS: Statistical Package for the Social Sciences (New York: McGraw-Hill Book Company, 1970), p. 209.

Most studies utilizing factor analysis employ the technique for exploratory purposes. Its use in this study was: 1) to reduce the original set of variables, 2) to determine if the variables group as previously conceived, and 3) to define more succinct indexes which describe the site-selection process.

"The beauty of factor analysis is that it takes thousands . . . of measurements and qualitative measurements and resolves them into distinct patterns of occurrence."[14] For example, the data matrix in this study contains (150 industries x 30 variables) 4500 pieces of information. Factor analysis permits one to identify patterns of relationships among these data which would be impossible for the human mind alone.

Factor analysis begins with the construction of a correlation matrix, usually through the use of Pearson product-moment correlation coefficients. In setting up the correlation matrix, the user of factor analysis has some alternatives; he may calculate correlations among variables (or attributes), in which case the approach is called R-factor analysis, or he may calculate "association" between individuals or objects, which is known as Q-factor analysis. We are primarily concerned with R-factor analysis in this study as the desire is to group or eliminate variables.[15]

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[13] Ibid.

[14] R. J. Rummel, "Understanding Factor Analysis," The Journal of Conflict Resolution, XI (December, 1967), p. 445.

The second step in factor analysis involves the reduction of the original set of variables to a set of new variables on the basis of the interrelations exhibited in the data. This involves one of two approaches, principal-component analysis and classical- or common-factor analysis. Principal-component analysis uses "defined" factors while classical-factor analysis uses "inferred" factors. This study utilizes the classical-factor analysis approach. The end result is p-number of factors which hopefully account for most of the original total variance of the data.

The final step in factor analysis involves the rotation of the p-dimensional axis to simplify the identification and naming of the factors. The options involve either an orthogonal rotation method or an oblique rotational method. "Orthogonal rotation is mathematically simpler to handle, while oblique factors are empirically more realistic."[16] The mathematical distinction is that orthogonal factors are uncorrelated, while oblique factors may be correlated. For this study an orthogonal rotation was utilized called VARIMAX which centers on simplifying the columns of a factor matrix — that is, the inferred factors.

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[15] John P. Van de Geer, Introduction to Multivatiate Analysis for the Social Sciences (San Francisco: W. H. Freeman and Company, 1971), p. 128-129. Recently studies have varied from the use of product-moment correlations to include rank-correlation coefficients and, in some cases, frequency data.

[16] Nie and others, p. 212.

The results of the factor analysis of measurements obtained on 30 variables for 157 industries along with simple statistical descriptions of the variables are presented in the next chapter.

CHAPTER IV

EMPIRICAL ANALYSIS

This chapter presents the results of an analysis of certain variables believed to be related to industrial site-selection events which have occurred in the ETDD region since 1950. Descriptive statistics of each variable are presented first, followed by the results of the factor analysis.

Descriptive Statistics

This analysis made use of a system of computer programs called the Statistical Package for the Social Sciences (SPSS) designed by Norman Nie and Dale Brent.[1] These package programs permit a variety of analysis procedures and means for presentation of results.

Description of Sample

This analysis is based upon a sample of 157 industries, 15 percent of the total number of industries in the region. Fifty percent of these industries located in the region since 1964 and 25 percent since 1968. Approximately 50 percent of the industries sampled had 50 employees or less, with 80 percent of the industries sampled with less than 200 employees. Only 2 percent of the sample had over 1000 employees.

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[1] Norman Nie, Dale H. Bent, and C. Hadlai Hull, SPSS: Statistical Package for the Social Sciences (New York: McGraw-Hill Book Company, 1970).

Table 8 presents a breakdown of the sample by SIC number relative to the total number of industries in the ETDD region. The mixture is proportional to the total regional mixture of industries when one considers that some SIC categories have few new industries.

Description of Variable Measurements

For each of the 157 industrial site-selection events analyzed, measurements were obtained for 30 variables. The tables which follow provide a statistical summary of these data. Appendix A contains a sample survey form used to record these measurements. Ordinal scores from one to ten were used for variables which required measurements of absolute or relative value: 1 = lowest value, and 10 = greatest value. Measurements requiring yes or no answers were scored: 1 = yes and 10 = no.

Measurement of the slope and drainage characteristics obtained for the industrial sample are presented in Tables 9 and 10 respectively. Flat sites (less than 1% slope) were scored 1 and steep slope sites (30% or greater) were scored 10. Preference for gentle sloping terrain is obvious from the data. These sites, however, were not always located in extensive flat areas. Many small local industries seem to prefer small flat sites which may be surrounded by steeper sloping land. Drainage conditions were assessed on the basis of (1-3) = no water problems, (4-7) = some problems, and (8-10) =

Industry Type	Number in Sample	Total Number of ETDD Industries in 1973[2]
SIC 20 - Food	15	112
SIC 22 - Textile	5	40
SIC 23 - Clothing	9	67
SIC 24 - Lumber	12	110
SIC 25 - Furniture	25	64
SIC 26 - Paper	4	7
SIC 27 - Printing	6	95
SIC 28 - Chemical	7	42
SIC 29 - Petroleum	1	10
SIC 30 - Rubber & Plastic	7	14
SIC 31 - Leather	2	15
SIC 32 - Stone, Clay	13	86
SIC 33 - Prim. Metals	6	18
SIC 34 - Fab. Metals	15	86
SIC 35 - Mach (Ex. Elec.)	7	75
SIC 36 - Elec. Mach.	8	25
SIC 37 - Trans	5	20
SIC 38 - Instruments	1	21
SIC 39 - Misc.	7	57
Totals	157	975

DISTRIBUTION OF SAMPLE BY SIC CATEGORY

TABLE 8

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[2] The total number of industries in 1974 is 1002. These figures are based upon a census conducted in 1972-73.

Value	Absolute Frequency	Relative Frequency (Percent)	Adjusted Frequency (Percent)	Cumulative Adj Freq (Percent)
1.00	37	23.6	23.6	23.6
2.00	33	21.0	21.0	44.6
3.00	35	22.3	22.3	66.9
4.00	26	16.6	16.6	83.4
5.00	15	9.6	9.6	93.0
6.00	6	3.8	3.8	96.8
7.00	1	0.6	0.6	97.5
8.00	2	1.3	1.3	98.7
9.00	2	1.3	1.3	100.0
0.0	0	0.0	Missing	100.0
Total	157	100.0	100.0	100.0

Statistics

Mean 2.955	Mode 1.000	Median 2.743	Kurtosis 1.186
Std Dev 1.715	Skewness 1.003	Variance 2.940	

Missing Observations 0

VARIABLE - SLOPE OF LAND

TABLE 9

Value	Absolute Frequency	Relative Frequency (Percent)	Adjusted Frequency (Percent)	Cumulative Adj Freq (Percent)
1.00	113	72.0	72.0	72.0
2.00	24	15.3	15.3	87.3
3.00	12	7.6	7.6	94.9
4.00	2	1.3	1.3	96.2
5.00	3	1.9	1.9	98.1
6.00	1	0.6	0.6	98.7
7.00	1	0.6	0.6	99.4
8.00	1	0.6	0.6	100.0
0.0	0	0.0	Missing	100.0
Total	157	100.0	100.0	100.0

Statistics

Mean 1.535 Mode 1.000 Median 0.0 Kurtosis 10.739

Std Dev 1.141 Skewness 3.031 Variance 1.302

Missing Observations 0

VARIABLE - DRAINAGE

TABLE 10

frequent problems. Most of the industrial sites examined appeared to have few or no problems with flooding.

Cover conditions present few problems in the site selection process simply because of the amount of land available which has already been cleared for agriculture. Sixty-three percent of the industries located on sites with no clearing problems at all (Table 11).

Measurements of the distance to the center of town were scored according to the position of the site relative to the urban developed area. For example, sites in or near the center of town were scored from 1-3, suburban or urban fringe sites from 4-7, and sites in rural or remote areas from 8-10. Suburban and urban fringe areas seem to be the preferred location of those industries sampled (Table 12).

Distance to the nearest major throughfare was included to measure the importance of proximity to main streets in the CBD or major routes radiating from the CBD. Sites adjacent to major throughfares were scored (1). Sites displaced 2 or 3 blocks were scored 2 to 4. Sites remote from major urban throughfares were scores 6-10. Most of the sites surveyed were located just off major urban throughfares (Table 13).

Measurements for the density of land use in the immediate vicinity of the site have a double-modal distribution reflecting industry preference for two types of sites, urban fringe sites of medium density, and historical industrial sites situated near the CBD (Table 14).

Value	Absolute Frequency	Relative Frequency (Percent)	Adjusted Frequency (Percent)	Cumulative Adj Freq (Percent)
1.00	95	60.5	63.3	63.3
2.00	11	7.0	7.3	70.7
3.00	8	5.1	5.3	76.0
4.00	7	4.5	4.7	80.7
5.00	2	1.3	1.3	92.0
6.00	7	4.5	4.7	86.7
7.00	7	4.5	4.7	91.3
8.00	5	3.2	3.3	94.7
9.00	5	3.2	3.3	98.0
10.00	3	1.9	2.0	100.0
0.0	7	4.5	Missing	100.0
Total	157	100.0	100.0	100.0

Statistics

Mean 2.567 Mode 1.000 Median 0.0 Kurtosis 0.927

Std Dev 2.597 Skewness 1.516 Variance 6.744

Missing Observations 7

VARIABLE - CLEARING-COVER CONDITIONS

TABLE 11

Value	Absolute Frequency	Relative Frequency (Percent)	Adjusted Frequency (Percent)	Cumulative Adj Freq (Percent)
1.00	12	7.6	7.7	7.7
2.00	12	7.6	7.7	15.4
3.00	23	14.6	14.7	30.1
4.00	12	7.6	7.7	37.8
5.00	29	18.5	18.6	56.4
6.00	12	7.6	7.7	64.1
7.00	17	10.8	10.9	75.0
8.00	14	8.9	9.0	84.0
9.00	14	8.9	9.0	92.9
10.00	11	7.0	7.1	100.0
0.0	1	0.6	Missing	100.0
Total	157	100.0	100.0	100.0

Statistics

Mean 5.365 Mode 5.000 Median 5.155 Kurtosis -1.027

Std Dev 2.650 Skewness 0.107 Variance 7.020

Missing Observations 1

VARIABLE - DISTANCE TO CENTER OF TOWN

TABLE 12

Value	Absolute Frequency	Relative Frequency (Percent)	Adjusted Frequency (Percent)	Cumulative Adj Freq (Percent)
1.00	49	31.2	31.8	31.8
2.00	83	52.9	53.9	85.7
3.00	18	11.5	11.7	97.4
5.00	2	1.3	1.3	93.7
6.00	1	0.6	0.6	99.4
10.00	1	0.6	0.6	100.0
0.0	3	1.9	Missing	100.0
Total	157	100.0	100.0	100.0

Statistics

Mean 1.916 Mode 2.000 Median 1.837 Kurtosis 24.461

Std Dev 1.035 Skewness 3.789 Variance 1.071

Missing Observations 3

VARIABLE - DISTANCE TO NEAREST MAJOR THROUGHFARE

TABLE 13

Value	Absolute Frequency	Relative Frequency (Percent)	Adjusted Frequency (Percent)	Cumulative Adj Freq (Percent)
1.00	28	17.8	17.9	17.9
2.00	16	10.2	10.3	28.2
3.00	29	18.5	18.6	46.8
4.00	13	8.3	8.3	55.1
5.00	6	3.8	3.8	59.0
6.00	14	8.9	9.0	67.9
7.00	16	10.2	10.3	78.2
8.00	12	7.6	7.7	85.9
9.00	17	10.8	10.9	96.8
10.00	5	3.2	3.2	100.0
0.0	1	0.6	Missing	100.0
Total	157	100.0	100.0	100.0

Statistics

Mean 4.641 Mode 3.000 Median 3.885 Kurtosis -1.273

Std Dev 2.878 Skewness 0.299 Variance 8.283

Missing Observations 1

VARIABLE - DENSITY OF LAND USE IN IMMEDIATE VICINITY

TABLE 14

Estimates of the unit price of land were based upon the location of the site relative to the CBD and major thoroughfares. The distribution is flat-topped (platykurtic) indicating industry prefers a middle range in land values (Table 15). This agrees with the theoretical statements noted in Chapter II.

Measurements of the proportion of urban area within 2-1/2 miles of the industrial site were included in the survey more for future analysis purposes than for the purpose of this study. Additional data necessary to give the measure meaning were not digitized at a fine enough scale at the time of this study. Census variables such as average value of housing, percent of workers in manufacturing, median family income, etc., are presently being digitized by census tract, enumeration districts, or aggregates of enumeration districts, called parcels. Approximately 189 variables are being stored and the additional programming assistance to acquire access to them was not available to this researcher.

Knowledge of the sample pattern permits one to interpret the frequency distribution in Table 16. Forty-five percent of the sample industrial sites were located in the Knoxville region and approximately 70 percent of these were located on the fringe of Knoxville. Because of the site of Knoxville, the 2-1/2 mile radius rarely encircled more than 40 percent (score = 4) of the urbanized area.[3] The

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[3] The 2-1/2 mile radius was selected on the basis of two considerations. If proximity to a suitable work force has any effect upon the site selection process, it was decided that 2-1/2 miles would be approximately the maximum distance which could be considered convenient to the work place. Secondly, the 2-1/2 mile dimension conveniently integrates with this cell dimension to be used in the ORNL land use model.

Value	Absolute Frequency	Relative Frequency (Percent)	Adjusted Frequency (Percent)	Cumulative Adj Freq (Percent)
1.00	4	2.5	2.6	2.6
2.00	13	10.8	8.4	11.0
3.00	17	10.8	11.0	22.1
4.00	17	10.8	11.0	33.1
5.00	16	10.2	10.4	43.5
6.00	24	15.3	15.6	59.1
7.00	30	19.1	19.5	78.6
8.00	21	13.4	13.6	92.2
9.00	11	7.0	7.1	99.4
10.00	1	0.6	0.6	100.0
0.0	3	1.9	Missing	100.0
Total	157	100.0	100.0	100.0

Statistics

Mean 5.584 Mode 7.000 Median 5.917 Kurtosis -0.934

Std Dev 2.210 Skewness -0.268 Variance 4.885

Missing Observations 3

VARIABLE - RATING OF PRICE OF LAND

TABLE 15

Value	Absolute Frequency	Relative Frequency (Percent)	Adjusted Frequency (Percent)	Cumulative Adj Freq (Percent)
1.00	46	29.3	29.3	29.3
2.00	15	9.6	9.6	38.9
3.00	6	3.8	3.8	42.7
4.00	22	14.0	14.0	56.7
5.00	7	4.5	4.5	61.1
6.00	4	2.5	2.5	63.7
7.00	5	3.2	3.2	66.9
8.00	15	9.6	9.6	76.4
9.00	13	8.3	8.3	84.7
10.00	24	15.3	15.3	100.0
0.0	0	0.0	Missing	100.0
Total	157	100.0	100.0	100.0

Statistics

Mean 4.796 Mode 1.000 Median 4.023 Kurtosis -1.490

Std Dev 3.469 Skewness 0.310 Variance 12.035

Missing Observations 0

VARIABLE - PROPORTION OF URBAN AREA
WITHIN TWO AND A HALF MILES

TABLE 16

remainder of the sample included sites near small communities and frequently the 2-1/2 mile circle would include most of the urbanized area (score = 8-10).

Distance to major highway was measured differently from distance to major thoroughfare. This measure was included to determine if proximity to federal and state highways functioning at the time of the location event affect site choices differently than proximity to major thoroughfares. Most of the sites were located close to major highways (Table 17); however, 10 sites were located in areas 10 or more miles from a major highway.

Distance to secondary road was intended to measure the importance of egress and ingress to the plant site. It was believed that most industries would prefer sites which did not require plant traffic to interact directly with a major highway. The distribution in Table 18 indicates response to this factor.

Although 60 percent of the sites examined were adjacent to railroads, the importance of rail accessibility in current location decisions is questionable. Many of the sites occupied in the last decade were inaccessible to rail service (score = 10) or they could be served only with great difficulty (score = 5-9) (Table 19).

Distance to waterway was considered to have potential site importance to only a few industry types. This study, however, is concerned with the development of a general site selection algorithm. Consequently distance to waterway was included. Sixty percent of the sites included in the study were inaccessible to TVA waterways (Table 20) indicating the importance of this factor to be relatively low for most industry types. Some of the sites near Knoxville, Lenoir City,

Value	Absolute Frequency	Relative Frequency (Percent)	Adjusted Frequency (Percent)	Cumulative Adj Freq (Percent)
1.00	36	22.9	22.9	22.9
2.00	101	64.3	64.3	87.3
3.00	10	6.4	6.4	93.6
5.00	2	1.3	1.3	94.9
10.00	8	5.1	5.1	100.0
0.0	0	0.0	Missing	100.0
Total	157	100.0	100.0	100.0

Statistics

Mean 2.280 Mode 2.000 Median 1.921 Kurtosis 11.143

Std Dev 1.901 Skewness 3.414 Variance 3.613

Missing Observations 0

VARIABLE - DISTANCE TO MAJOR HIGHWAY

TABLE 17

Value	Absolute Frequency	Relative Frequency (Percent)	Adjusted Frequency (Percent)	Cumulative Adj Freq (Percent)
1.00	146	93.0	93.0	93.0
2.00	8	5.1	5.1	98.1
3.00	2	1.3	1.3	99.4
5.00	1	0.6	0.6	100.0
0.0	0	0.0	Missing	100.0
Total	157	100.0	100.0	100.0

Statistics

Mean 1.102 Mode 1.000 Median 1.0 Kurtosis 41.611

Std Dev 0.441 Skewness 5.881 Variance 0.195

Missing Observations 0

VARIABLE - DISTANCE TO SECONDARY ROAD

TABLE 18

Value	Absolute Frequency	Relative Frequency (Percent)	Adjusted Frequency (Percent)	Cumulative Adj Freq (Percent)
1.00	80	51.0	51.0	51.0
2.00	17	10.8	10.8	61.8
3.00	6	3.8	3.8	65.6
4.00	5	3.2	3.2	68.8
5.00	2	1.3	1.3	70.1
6.00	5	3.2	3.2	73.2
7.00	3	1.9	1.9	75.2
8.00	12	7.6	7.6	82.8
9.00	1	0.6	0.6	83.4
10.00	26	16.6	16.6	100.0
0.0	0	0.0	Missing	100.0
Total	157	100.0	100.0	100.0

Statistics

Mean 3.682 Mode 1.000 Median 1.3 Kurtosis -0.950

Std Dev 3.563 Skewness 0.886 Variance 12.693

Missing Observations 0

VARIABLE - DISTANCE TO RAILWAY

TABLE 19

Value	Absolute Frequency	Relative Frequency (Percent)	Adjusted Frequency (Percent)	Cumulative Adj Freq (Percent)
1.00	3	1.9	1.9	1.9
2.00	8	5.1	5.1	7.1
3.00	5	3.2	3.2	10.3
4.00	5	3.2	3.2	13.5
5.00	6	3.8	3.8	17.3
6.00	3	1.9	1.9	19.2
7.00	5	3.2	3.2	22.4
8.00	14	8.9	9.0	31.4
9.00	10	6.4	6.4	37.8
10.00	97	61.8	62.2	100.0
0.0	1	0.6	Missing	100.0
Total	157	100.0	100.0	100.0

Statistics

Mean 8.391 Mode 10.000 Median 9.3 Kurtosis 0.967

Std Dev 2.646 Skewness -1.534 Variance 7.001

Missing Observations 1

VARIABLE - DISTANCE TO WATERWAY

TABLE 20

and Loudon were close to public docks and, therefore, received lower accessibility values, but only three sites surveyed had dock-site access at the plant.

Commercial airport accessibility may be considered as both a regional influence and a local influence in industrial site selection decisions particularly in the case of small to medium-sized industries. The effect of small airports in the decision process was not considered due to the widespread distribution of private and municipal airports throughout the region. The frequency distribution probably reflects the regional spread of industry more than the importance of the factor in the site selection process (Table 21).

Distance to Interstate highway interchange measures the importance that proximity to the Interstate system may have on the site selection process. Sites within two miles were scored a 1; sites farther away were scored on the basis of 2-mile increments for each number assigned. Approximately 90 percent of the industries surveyed have located or relocated since the Interstate highway system was created in 1956. Eighty-eight percent of the sites were within eight miles of an interchange (Table 22).

Two measures of the overall quality of accessibility were included in this analysis to determine if a collective measure of accessibility would be significantly different from individual measures of accessibility and to determine if the overall quality of the accessibility has significantly changed since the location event. The latter may indicate whether industry location may influence future transportation improvements. The measures were overall quality of accessibility then

Value	Absolute Frequency	Relative Frequency (Percent)	Adjusted Frequency (Percent)	Cumulative Adj Freq (Percent)
1.00	1	0.6	0.6	0.6
2.00	8	5.1	5.1	5.8
3.00	32	20.4	20.5	26.3
4.00	14	8.9	9.0	35.3
5.00	12	7.6	7.7	42.9
6.00	3	1.9	1.9	44.9
7.00	2	1.3	1.3	46.2
8.00	6	3.8	3.8	50.0
9.00	2	1.3	1.3	51.3
10.00	76	48.4	48.7	100.0
0.0	1	0.6	Missing	100.0
Total	157	100.0	100.0	100.0

Statistics

Mean 6.968	Mode 10.000	Median 8.500	Kurtosis -1.708
Std Dev 3.236		Skewness -0.289	Variance 10.470

Missing Observations 1

VARIABLE - DISTANCE TO AIRPORT

TABLE 21

Value	Absolute Frequency	Relative Frequency (Percent)	Adjusted Frequency (Percent)	Cumulative Adj Freq (Percent)
1.00	58	36.9	37.4	37.4
2.00	21	13.4	13.5	51.0
3.00	48	30.6	31.0	81.9
4.00	10	6.4	6.5	88.4
6.00	6	3.8	3.9	92.3
8.00	2	1.3	1.3	93.5
10.00	10	6.4	6.5	100.0
0.0	2	1.3	Missing	100.0
Total	157	100.0	100.0	100.0

Statistics

Mean 2.813 Mode 1.000 Median 2.429 Kurtosis 3.285

Std Dev 2.352 Skewness 1.927 Variance 5.530

Missing Observations 2

VARIABLE - DISTANCE TO NEAREST INTERSTATE

TABLE 22

(Table 23) and overall quality of accessibility now (Table 24). Some improvement can be noted (the mean distance changed from 4.55 to 4.10). Overall accessibility now was not incorporated into the factor analysis.

Tables 25, 26, and 27 reflect measurements of the availability of utilities at the site before the industrial location event. In 90 percent of the cases, both water and gas were available at the site and in approximately 70 percent of the cases municipal sewage was available. It was noted that many industries locate beyond the city limits to avoid restrictions but enjoy other city benefits. In such instances only minimum sewage treatment is required and the industries will install their own facilities. This is reflected by the lower percentage of sites selected having preexisting sewage treatment facilities.

Table 28, 29, and 30 reflect measurements of compatibility associated with the sites surveyed. Attributes which were measured include: Did the community have zoning at the time of the event? Was the site zoned for industry? and Was industry already in the immediate area? Industrial zoning affects site selection significantly (60 percent of the sites examined were located in areas zoned for industry). This is interesting considering Tennessee does not require counties to exercise zoning control and consequently industry is not restricted by public policy in site selection. County governments, however, can exercise quasi-zoning control by limiting cooperation in road construction and other services. The existence of other industries nearby the potential sites also appears to be a strong

Value	Absolute Frequency	Relative Frequency (Percent)	Adjusted Frequency (Percent)	Cumulative Adj Freq (Percent)
1.00	1	0.6	0.6	0.6
2.00	14	8.9	9.1	9.7
3.00	24	15.3	15.6	25.3
4.00	24	15.3	15.6	40.9
5.00	60	38.2	39.0	79.9
6.00	20	12.7	13.0	92.9
7.00	4	2.5	2.6	95.5
8.00	7	4.5	4.5	100.0
0.0	3	1.9	Missing	100.0
Total	157	100.0	100.0	100.0

Statistics

Mean 4.552 Mode 5.000 Median 4.733 Kurtosis -0.007

Std Dev 1.469 Skewness 0.084 Variance 2.157

Missing Observations 3

VARIABLE - OVERALL QUALITY OF ACCESSIBILITY-THEN

TABLE 23

Value	Absolute Frequency	Relative Frequency (Percent)	Adjusted Frequency (Percent)	Cumulative Adj Freq (Percent)
1.00	5	3.2	3.2	3.2
2.00	17	10.8	11.0	14.3
3.00	26	16.6	16.6	31.2
4.00	53	33.8	34.4	65.6
5.00	30	19.1	19.5	85.1
6.00	13	8.3	8.4	93.5
7.00	6	3.8	3.9	97.4
8.00	3	1.9	1.9	99.4
9.00	1	0.6	0.6	100.0
0.0	3	1.9	Missing	100.0
Total	157	100.0	100.0	100.0

Statistics

Mean 4.104 Mode 4.000 Median 4.047 Kurtosis 0.481

Std Dev 1.505 Skewness 0.400 Variance 2.264

Missing Observations 3

VARIABLE - OVERALL QUALITY OF ACCESSIBILITY—NOW

TABLE 24

	Value	Absolute Frequency	Relative Frequency (Percent)	Adjusted Frequency (Percent)
Yes	1.00	141	89.8	89.8
No	10.00	16	10.2	10.2
	0.0	0	0.0	Missing
	Total	157	100.0	100.0

VARIABLE - CITY WATER AVAILABILITY

TABLE 25

	Value	Absolute Frequency	Relative Frequency (Percent)	Adjusted Frequency (Percent)
Yes	1.00	106	67.5	69.3
No	10.00	47	29.9	30.7
	0.0	4	2.5	Missing
	Total	157	100.0	100.0

VARIABLE - CITY SEWAGE AVAILABILITY

TABLE 26

	Value	Absolute Frequency	Relative Frequency (Percent)	Adjusted Frequency (Percent)
Yes	1.00	137	87.3	87.3
No	10.00	20	12.7	12.7
	0.0	0	0.0	Missing
		157	100.0	100.0

VARIABLE - GAS AVAILABILITY

TABLE 27

	Value	Absolute Frequency	Relative Frequency (Percent)	Adjusted Frequency (Percent)
Yes	1.00	98	62.4	63.2
No	10.00	57	36.3	36.7
	0.0	2	1.3	Missing
	Total	157	100.0	100.0

VARIABLE - DID COMMUNITY HAVE ZONING THEN?

TABLE 28

	Value	Absolute Frequency	Relative Frequency (Percent)	Adjusted Frequency (Percent)
Yes	1.00	87	55.4	65.9
No	10.00	45	28.7	34.1
	0.0	25	15.9	Missing
	Total	157	100.0	100.0

VARIABLE - WAS SITE ZONED FOR INDUSTRY?

TABLE 29

	Value	Absolute Frequency	Relative Frequency (Percent)	Adjusted Frequency (Percent)
Yes	1.00	110	70.1	71.4
No	10.00	44	28.0	28.6
	0.0	3	1.9	Missing
	Total	157	100.0	100.0

VARIABLE - WAS INDUSTRY ALREADY IN AREA?

TABLE 30

influence in the site selection process. This applies in both urban fringe and near CBD cases.

In lieu of recording each type of land use adjacent to the sites surveyed, an aggregate measure of land use compatibility (the overall rating of continuous land use compatibility) was included. Measurements varied from 1 = no problem with adjoining land use (e.g., situations with industry all around or open farm land or forest land all around) to 10 = significant compatibility problems (e.g., situations where the site was adjacent to a wealthy neighborhood, a hospital, or recreation area. Very few sites were objectionably located and most of those cases were in small communities where complainants would be few (Table 31).

Condition of neighborhood was included to measure the effect of value of housing on site selection processes. This was also considered a surrogate measure of family income and worker occupation types nearby the sites. Difficulty was incurred in applying the measure to sites in rural or open land. As can be seen from Table 32, the distribution is platykurtic with some skewness toward low quality neighborhoods.

The number of community services nearby the site was assessed to determine if proximity to gas stations, restaurants, parks, golf courses, clubs, banks, and other commercial development affected industrial site selection. Table 33 indicates that 70 percent of the sites had at least two services nearby and 30 percent had four or more Measurements of this variable, however, present problems when industries locate near existing industrial development. In subsequent

Value	Absolute Frequency	Relative Frequency (Percent)	Adjusted Frequency (Percent)	Cumulative Adj Freq (Percent)
1.00	58	36.9	37.7	37.7
2.00	30	19.1	19.5	57.1
3.00	26	16.6	16.9	74.0
4.00	19	12.1	12.3	86.4
5.00	11	7.0	7.1	93.5
6.00	5	3.2	3.2	96.8
7.00	3	1.9	1.9	98.7
8.00	2	1.3	1.3	100.0
0.0	3	1.9	Missing	100.0
Total	157	100.0	100.0	100.0

Statistics

Mean 2.558 Mode 1.000 Median 2.133 Kurtosis 0.566

Std Dev 1.692 Skewness 1.061 Variance 2.863

Missing Observations 3

VARIABLE - OVERALL RATING OF CONTIGUOUS LAND USE COMPATIBILITY

TABLE 31

Value	Absolute Frequency	Relative Frequency (Percent)	Adjusted Frequency (Percent)	Cumulative Adj Freq (Percent)
2.00	3	1.9	2.0	2.0
3.00	22	14.0	14.7	16.7
4.00	26	16.6	17.3	34.0
5.00	35	22.3	23.3	57.3
6.00	26	16.6	17.3	74.7
7.00	17	10.8	11.3	86.0
8.00	17	10.8	11.3	97.3
9.00	4	2.5	2.7	100.0
0.0	7	4.5	Missing	100.0
Total	157	100.0	100.0	100.0

Statistics

Mean 5.320 Mode 5.000 Median 5.186 Kurtosis -0.771

Std Dev 1.712 Skewness 0.228 Variance 2.930

Missing Observations 7

VARIABLE - CONDITION OF NEIGHBORHOOD

TABLE 32

Value	Absolute Frequency	Relative Frequency (Percent)	Adjusted Frequency (Percent)	Cumulative Adj Freq (Percent)
1.00	34	21.7	22.7	22.7
2.00	20	12.7	13.3	36.0
3.00	24	15.3	16.0	52.0
4.00	7	4.5	4.7	56.7
5.00	14	8.9	9.3	66.0
6.00	6	3.8	4.0	70.0
7.00	11	7.0	7.3	77.3
8.00	13	8.3	8.7	86.0
9.00	19	12.1	12.7	98.7
10.00	2	1.3	1.3	100.0
0.0	7	4.5	Missing	100.0
Total	157	100.0	100.0	100.0

Statistics

Mean 4.347 Mode 1.000 Median 3.375 Kurtosis -1.288

Std Dev 2.936 Skewness 0.414 Variance 8.617

Missing Observations 7

VARIABLE - DENSITY OF LAND USE

TABLE 33

studies, it is believed that some control should be introduced if industry presently exists in the vicinity of the site surveyed.

It was posited that designated industrial park space would be a strong variable in industrial site selection. Only 37 percent of the industry located in industrial parks (Table 34). However, many recent industries have located in industrial parks indicating a trend toward such locations.

Additional data concerning industrial park quality was collected but not included in the analysis because of the high percentage of missing observations (63.1 percent). Table 35, however, indicated the distribution of the data collected.

Finally, three additional variables were included in the analysis. These were: (1) Proximity of site to Knoxville; (2) Amount of other industry located nearby; and (3) Was a suitable building already there? (Tables 36, 37, and 38).

Proximity to Knoxville was included to determine if sites oriented toward Knoxville had an impact on the process. Some effect is indicated (low values = orientation toward Knoxville) but a large percent of the sample came from the Knoxville vicinity. In any subsequent study the Knoxville sample will be eliminated from the analysis.

The existence of a suitable building at the site seems to have influenced the decision process to some extent (30 percent). Also the amount of industry nearby seems to have influenced location decisions.

Value	Absolute Frequency	Relative Frequency (Percent)	Adjusted Frequency (Percent)	Cumulative Adj Freq (Percent)
1.00	18	11.5	12.2	12.2
2.00	8	5.1	5.4	17.6
3.00	8	5.1	5.4	23.0
4.00	7	4.5	4.7	27.7
5.00	11	7.0	7.4	35.1
6.00	11	7.0	7.4	42.6
7.00	15	9.6	10.1	52.7
8.00	21	13.4	14.2	66.9
9.00	22	14.0	14.9	81.8
10.00	27	17.2	18.2	100.0
0.0	9	5.7	Missing	100.0
Total	157	100.0	100.0	100.0

Statistics

Mean 6.405 Mode 10.000 Median 7.233 Kurtosis -1.066

Std Dev 3.079 Skewness -0.525 Variance 9.481

Missing Observations 9

VARIABLE - NEARBY COMMUNITY SERVICES

TABLE 34

Value	Absolute Frequency	Relative Frequency (Percent)	Adjusted Frequency (Percent)	Cumulative Adj Freq (Percent)
1.00	58	36.9	37.2	37.2
10.00	98	62.4	62.8	100.0
0.0	1	0.6	Missing	100.0
Total	157	100.0	100.0	100.0

Statistics

Mean 6.654 Mode 10.000 Median 0.0 Kurtosis -1.719

Std Dev 4.364 Skewness -0.531 Variance 19.041

Missing Observations 1

VARIABLE - WAS THE SITE IN AN INDUSTRIAL PARK?

TABLE 35

Value	Absolute Frequency	Relative Frequency (Percent)	Adjusted Frequency (Percent)	Cumulative Adj Freq (Percent)
1.00	8	5.1	13.8	13.8
2.00	9	5.7	15.5	29.3
3.00	11	7.0	19.0	48.3
4.00	14	8.9	24.1	72.4
5.00	9	5.7	15.5	87.9
6.00	4	2.5	6.9	94.8
7.00	3	1.9	5.2	100.0
0.0	99	63.1	Missing	100.0
Total	157	100.0	100.0	100.0

Statistics

Mean 3.534 Mode 4.000 Median 3.571 Kurtosis -0.681

Std Dev 1.667 Skewness 0.191 Variance 2.779

Missing Observations 99

VARIABLE - WHAT WAS THE QUALITY OF THE PARK?

TABLE 36

Value	Absolute Frequency	Relative Frequency (Percent)	Adjusted Frequency (Percent)	Cumulative Adj Freq (Percent)
1.00	16	10.2	10.2	10.2
2.00	29	18.5	18.5	28.7
3.00	29	18.5	18.5	47.1
4.00	26	16.6	16.6	63.7
5.00	8	5.1	5.1	68.8
6.00	7	4.5	4.5	73.2
7.00	12	7.6	7.6	80.9
8.00	15	9.6	9.6	90.4
9.00	10	6.4	6.4	96.8
10.00	5	3.2	3.2	100.0
0.0	0	0.0	Missing	100.0
Total	157	100.0	100.0	100.0

Statistics

Mean 4.401 Mode 2.000 Median 3.673 Kurtosis -0.876

Std Dev 2.628 Skewness 0.594 Variance 6.908

Missing Observations 0

VARIABLE - PROXIMITY TO KNOXVILLE

TABLE 37

Value	Absolute Frequency	Relative Frequency (Percent)	Adjusted Frequency (Percent)	Cumulative Adj Freq (Percent)
1.00	30	19.1	19.4	19.4
2.00	9	5.7	5.8	25.2
3.00	10	6.4	6.5	31.6
4.00	6	3.8	3.9	35.5
5.00	14	8.9	9.0	44.5
6.00	8	5.1	5.2	49.7
7.00	12	7.6	7.7	57.4
8.00	21	13.4	13.5	71.0
9.00	13	8.3	8.4	79.4
10.00	32	20.4	20.6	100.0
0.0	2	1.3	Missing	100.0
Total	157	100.0	100.0	100.0

Statistics

Mean 5.865 Mode 10.000 Median 6.542 Kurtosis -1.439

Std Dev 3.365 Skewness -0.234 Variance 11.326

Missing Observations 2

VARIABLE - AMOUNT OF OTHER INDUSTRY LOCATED NEARBY

TABLE 38

Results of the Factor Analysis

The SPSS factor analysis procedures were discussed in the preceding chapter and will not be repeated here. Table 39 presents the correlation coefficient matrix for 27 variables utilized in the factor analysis. Correlation values greater than ±.50 are considered to be significant. In general, the values associated with each pair of variables agrees with theoretical expectations.

Eigen values associated with the initial factor matrix are found in Table 40. The eigen-values represent the proportion of the standardized total variance (27) accounted for by each factor. The SPSS factor analysis routine automatically stops extracting factors when the eigen-value for a factor falls below one. This assures that only factors accounting for at least the average total variance (1/27) will be treated as significant. In this case seven factors were extracted accounting for 72 percent of the original variance.

Some explanation of the "loadings" or "scores" found in the factor matrix is necessary before discussing the results of this analysis. Scores found in the factor matrix are evaluated similar to correlation or regression coefficients. Values may range from +1 to -1. The greater the absolute value of the score, the greater the relationship between the factor and the variable. The level at which factor loadings may be considered as significant is open to question. Most statisticians suggest that loadings greater than .50 should be considered significant. Ideally, only a small number of variables should load significantly on more than one column in the matrix. Variables loading on more than one factor complicate the interpretation

	Row	Columns 1	2	3	4	5	6	7	8	9
Slope of land	1	1.000	-.247	.519	.132	-.007	-.126	-.088	-.130	.055
Drainage	2	-.247	1.000	-.027	.070	.088	-.093	-.065	.013	.013
Clearing-cover conditions	3	.519	-.027	1.000	.146	.048	-.143	-.143	-.141	.038
Distance to center of town	4	.132	.070	.146	1.000	.206	-.814	-.529	-.180	.223
Distance to nearest major throughfare	5	-.007	.088	.048	.206	1.000	-.223	-.110	-.218	.345
Density of land use in immediate vicinity	6	-.126	-.093	-.143	-.814	-.223	1.000	.500	.244	-.214
Rating of price of land	7	-.088	-.065	-.143	-.529	-.110	.500	1.000	-.047	-.315
Percent of urban area within 2-1/2 miles	8	-.130	.013	-.141	-.180	-.218	.244	-.047	1.000	.169
Distance to major highway	9	.055	.013	.038	.223	.345	-.214	-.315	.169	1.000
Distance to secondary road	10	.074	-.033	-.075	.083	-.208	-.158	-.248	-.078	-.157
Distance to railway	11	.150	-.114	.158	.082	.074	.028	-.312	-.023	.055
Distance to airport	12	-.054	.138	-.032	.399	.016	-.413	-.338	.350	.154
Distance to waterway	13	.018	.058	.135	.315	-.011	-.232	-.256	.222	.121
Distance to nearest Interstate	14	.049	-.066	-.031	.390	.188	-.373	-.426	.275	.702
Overall quality of accessibility - then	15	.036	.076	.087	.427	.081	-.363	-.503	.277	.472
City water availability	16	.350	.053	.203	.401	.070	-.347	-.370	-.085	.122
Gas availability	17	.250	.028	.150	.388	.203	-.299	-.521	.148	.624
City sewage availability	18	.184	.088	.140	.493	.143	-.495	-.647	-.079	.141
Did community have zoning then?	19	-.001	.084	.031	.225	-.014	-.162	-.503	.360	.205
Was it zoned for industry?	20	.113	.034	.128	.351	.060	-.248	-.638	.149	.248
Was industry already in area?	21	.147	.078	.167	.350	.47	-.223	-.491	.114	.249
Was a building already there?	22	.120	-.073	.138	.372	-.061	-.449	-.107	-.240	.105
Rating of land use compatibility	23	-.070	-.168	-.013	-.246	-.247	.298	-.038	.299	-.040
Nearby community services	24	-.225	-.033	-.261	-.650	-.093	.637	.608	.063	-.117
Was the site in an industrial park?	25	-.038	.072	.015	-.129	-.037	.201	-.335	.336	-.081
Proximity to Knoxville	26	.121	.026	.013	.409	.100	-.405	-.300	.159	.203
Amount of other industry located nearby	27	-.137	-.046	-.227	-.486	-.093	.434	.696	-.136	-.205

CORRELATION MATRIX

TABLE 39

	Row	Columns								
		10	11	12	13	14	15	16	17	18
Slope of land	1	.074	.150	-.054	.018	.049	.036	.350	.250	.184
Drainage	2	-.033	-.114	.138	.058	-.066	.076	.053	.028	.088
Clearing-cover conditions	3	-.075	.158	-.032	.135	-.031	.087	.203	.150	.140
Distance to center of town	4	.083	.082	.399	.315	.390	.427	.401	.388	.493
Distance to nearest major throughfare	5	-.208	.074	.016	-.011	.188	.081	.070	.203	.143
Density of land use in immediate vicinity	6	-.158	.028	-.413	-.232	-.373	-.363	-.347	-.299	-.495
Rating of price of land	7	-.248	-.312	-.338	-.256	-.426	-.503	-.370	-.521	-.647
Percent of urban area within 2-1/2 miles	8	-.078	-.023	.350	.222	.275	.277	-.085	.148	-.079
Distance to major highway	9	-.157	.055	.154	.121	.702	.472	.122	.624	.141
Distance to secondary road	10	1.000	.045	.124	.081	.075	.119	.022	.046	.289
Distance to railway	11	.045	1.000	-.144	.188	-.010	.388	.078	.116	.304
Distance to airport	12	.124	-.144	1.000	.646	.465	.701	.124	.295	.292
Distance to waterway	13	.081	.188	.646	1.000	.278	.736	-.052	.231	.207
Distance to nearest interstate	14	.075	-.010	.465	.278	1.000	.599	.175	.710	.264
Overall quality of accessibility - then	15	.119	.388	.701	.736	.599	1.000	.132	.513	.407
City water availability	16	.022	.078	.124	-.052	.175	.132	1.000	.479	.472
Gas availability	17	.046	.116	.295	.231	.710	.513	.479	1.000	.390
City sewage availability	18	.289	.304	.292	.207	.264	.407	.472	.390	1.000
Did community have zoning then?	19	.246	.003	.434	.220	.355	.376	.243	.404	.525
Was it zoned for industry?	20	.264	.106	.346	.225	.446	.465	.453	.500	.605
Was industry already in area?	21	.089	.324	.178	.243	.311	.392	.272	.414	.444
Was a building already there?	22	.020	-.061	.183	.196	.108	.122	.177	.112	.080
Rating of land use compatibility	23	-.043	.354	-.066	.089	-.036	.165	-.180	-.074	-.090
Nearby community services	24	-.109	-.032	-.351	-.302	-.210	-.288	-.441	-.271	-.494
Was the site in an industrial park?	25	.179	.107	.143	.009	.047	.141	.151	.156	.365
Proximity to Knoxville	26	.180	-.040	.752	.544	.472	.612	.180	.329	.251
Amount of other industry located nearby	27	-.195	-.353	-.363	-.358	-.353	-.527	-.352	-.449	-.651

TABLE 39 - Continued

	Row	19	20	21	22	23	24	25	26	27
Slope of land	1	-.001	.113	.147	.120	-.070	-.225	-.038	.121	-.137
Drainage	2	.084	.034	.078	-.073	-.168	-.033	.072	.026	-.046
Clearing-cover conditions	3	.031	.128	.167	.138	-.013	-.261	.015	.013	-.227
Distance to center of town	4	.225	.351	.350	.372	-.246	-.650	-.129	.409	-.486
Distance to nearest major throughfare	5	-.014	.060	.147	-.061	-.247	-.093	-.037	.100	-.093
Density of land use in immediate vicinity	6	-.162	-.248	-.223	-.449	.298	.637	.201	-.405	.434
Rating of price of land	7	-.503	-.638	-.491	-.107	-.038	.608	-.335	-.300	.696
Percent of urban area within 2-1/2 miles	8	.360	.149	.114	-.240	.299	.063	.336	.159	-.136
Distance to major highway	9	.205	.248	.249	.105	-.040	-.117	-.081	.203	-.205
Distance to secondary road	10	.246	.264	.089	.020	-.043	-.109	.179	.180	-.195
Distance to railway	11	.003	.106	.324	-.061	.354	-.032	.107	-.040	-.353
Distance to airport	12	.434	.346	.178	.183	-.066	-.351	.143	.732	-.363
Distance to waterway	13	.220	.225	.243	.196	.089	-.302	.009	.544	-.358
Distance to nearest interstate	14	.355	.446	.311	.108	-.036	-.210	.047	.472	-.353
Overall quality of accessibility - then	15	.376	.465	.392	.122	.165	-.288	.141	.612	-.527
City water availability	16	.243	.453	.272	.117	-.180	-.441	.151	.180	-.352
Gas availability	17	.404	.500	.414	.112	-.074	-.271	.156	.329	-.449
City sewage availability	18	.525	.605	.444	.080	-.090	-.494	.365	.251	-.651
Did community have zoning then?	19	1.000	.849	.437	-.038	.038	-.293	.532	.277	-.471
Was it zoned for industry?	20	.849	1.000	.580	.001	.106	-.366	.508	.251	-.606
Was industry already in area?	21	.437	.580	1.000	-.080	.111	-.364	.373	.244	-.737
Was a building already there?	22	-.038	.001	-.080	1.000	-.264	-.265	-.437	.162	.045
Rating of land use compatibility	23	.038	.106	.111	-.264	1.000	.232	.193	-.115	-.200
Nearby community services	24	-.293	-.366	-.364	-.265	.232	1.000	-.076	-.368	.563
Was the site in an industrial park?	25	.532	.508	.373	-.437	.193	-.076	1.000	-.011	-.433
Proximity to Knoxville	26	.277	.251	.244	.162	-.115	-.368	-.011	1.000	-.319
Amount of other industry located nearby	27	-.471	-.606	-.737	.045	-.200	.563	-.433	-.319	1.000

TABLE 39 - Continued

Factor	Eigen Value	Pct. of Var.	Cum. Pct.
1	7.79292	28.9	28.9
2	3.02117	11.2	40.1
3	2.02117	9.2	49.3
4	1.87910	7.0	56.2
5	1.75885	6.5	62.7
6	1.39755	5.2	67.9
7	1.17964	4.4	72.3
8	0.94247	3.5	75.8
9	0.84998	3.1	78.9
10	0.75369	2.8	81.7
11	0.67677	2.5	84.2
12	0.56666	2.1	86.3
13	0.53530	2.0	88.3
14	0.42438	1.6	89.9
15	0.37718	1.4	91.3
16	0.35815	1.3	92.6
17	0.33950	1.3	93.8
18	0.32075	1.2	95.0
19	0.28415	1.1	96.1
20	0.23591	0.9	97.0
21	0.18443	0.7	97.6
22	0.17080	0.6	98.3
23	0.15223	0.6	98.8
24	0.12058	0.4	99.3
25	0.10901	0.4	99.7
26	0.07168	0.3	100.0
27	0.01322	0.0	100.0

EIGEN-VALUES

TABLE 40

of factors. Columns with a high number of significant loadings should have at least as many near zero loadings as the number of factors derived.[4]

Attention is directed to a comparison between the unrotated factor matrix (Table 41) and the rotated factor matrix (Table 42). Note that rotation of the axis simplifies interpretation of the factors. In interpreting the rotated matrix, the original 27 variables have been collapsed to seven factors accounting for 72 percent of the original variance. Approximately 20 variables can be identified as significant. The following list summarizes the variables which load significantly on each factor.

FACTOR I[5]

ZONED INDUSTRY
ZONING PRESENT
AMOUNT OF OTHER INDUSTRY LOCATED NEARBY
SEWAGE AVAILABLE
PRICE OF LAND
SITE IN INDUSTRIAL PARK
(INDUSTRY IN AREA)

FACTOR II

DISTANCE TO AIRPORT
DISTANCE TO WATERWAY
OVERALL QUALITY OF ACCESSIBILITY-THEN
PROXIMITY TO KNOXVILLE

FACTOR III

DENSITY OF LAND USE
DISTANCE TO CENTER OF TOWN
BUILDING PRESENT
(SITE IN INDUSTRIAL PARK)
(PERCENT OF URBAN AREA WITHIN TWO AND A HALF MILES)

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[4] Nie and others, p. 223.

[5] Variables are listed from highest factor score to lowest. Parentheses indicate variables with questionable significant loadings.

	Factors						
	1	2	3	4	5	6	7
Slope of land	-.2067	.2232	.4081	-.2240	.3973	.6317	-.0849
Drainage	-.0736	.0004	-.0584	.1243	-.2121	-.1658	-.2396
Clearing-cover conditions	-.1970	.1483	.3035	-.0923	.3060	.2306	-.1781
Distance to center of town	-.6782	.4880	.0749	.1088	-.0269	-.1692	.0318
Distance to nearest major throughfare	-.1730	.2049	.0288	-.3079	-.1480	-.2576	-.3660
Density of land use in immediate vicinity	.6229	-.6059	-.0571	-.1640	.0894	.1659	-.0844
Rating of price of land	.7796	.0663	-.2166	-.0212	.0331	.1725	-.1362
Percent of urban area within 2-1/2 miles	-.1510	-.5074	-.3812	-.0212	-.0148	.1727	-.0253
Distance to major highway	-.4427	.0672	-.2789	-.6941	-.1252	-.0814	.0108
Distance to secondary road	-.2102	-.0816	.1052	.2768	-.0355	.0772	.2752
Distance to railway	-.2260	-.2168	.2428	-.1532	.5634	-.3284	.0710
Distance to airport	-.6374	.0250	-.5857	.3787	-.0210	.1872	-.1563
Distance to waterway	-.5026	-.0003	-.4337	.2364	.3990	.0001	-.1052
Distance to nearest Interstate	-.6462	.0167	-.3867	-.4301	-.1635	.0667	.1739
Overall quality of accessibility-then	-.7644	-.1117	-.4355	-.0424	.3435	-.1096	.0075
City water availability	-.4629	.1492	.3647	-.0729	-.1296	.1805	-.0520
Gas availability	-.6793	.0012	-.0393	-.4660	-.1118	.1364	.0283
City sewage availability	-.7034	-.0302	.3539	.1357	-.0660	-.1021	.0363
Did community have zoning then?	-.6303	-.4140	.0404	.1291	-.3171	.1801	.1013
Was it zoned for industry?	-.7458	-.3441	.2116	.0187	-.2270	.1215	.1477
Was industry already in area?	-.6126	-.2440	.2245	-.0833	.0712	-.1265	-.1383
Was a building already there?	-.1761	.5503	-.0764	.0748	.0769	.0734	.2634
Rating of land use compatibility	.0372	-.5217	-.0405	-.0538	.3853	-.1041	.1835
Nearby community services	.6336	-.3111	-.2232	-.2228	.0101	-.0049	.0809
Was the site in an industrial park?	-.2980	-.6928	.2429	.1432	-.1896	.0685	-.1857
Proximity to Knoxville	-.5761	.1559	-.4078	.1766	.0794	.1646	-.1097
Amount of other industry located nearby	.7873	.2211	-.2532	-.0800	-.1499	.1823	.0858

UNROTATED FACTOR MATRIX

TABLE 41

	Factors						
	1	2	3	4	5	6	7
Slope of land	.0680	-.0152	-.0857	.0798	.9102	-.0036	.1625
Drainage	.1066	.0854	-.0042	-.0774	-.1740	-.1210	-.2908
Clearing-cover conditions	.1004	.0302	-.0999	-.0263	.5481	.1176	-.0644
Distance to center of town	.3789	.2791	-.6820	.1617	.0756	.0295	-.1634
Distance to nearest major throughfare	.0263	-.0487	-.1359	.2455	.0308	.0107	-.5540
Density of land use in immediate vicinity	-.3218	-.2540	.7884	-.1284	-.0314	.0584	.1319
Rating of price of land	-.7079	-.1708	.2698	-.2332	-.0151	-.2251	.0242
Percent of urban area within 2-1/2 miles	.1087	.3475	.5006	.1897	-.1362	-.0204	.1361
Distance to major highway	.0515	.0920	-.0500	.8469	.0081	.0742	-.2148
Distance to secondary road	.3127	.0697	-.1052	-.1105	-.0575	-.0197	.3031
Distance to railway	.1630	-.0041	.0091	.0179	.1473	.7497	-.0069
Distance to airport	.2474	.9025	-.0835	.1036	-.0909	-.2272	.0002
Distance to waterway	.0818	.7715	-.0879	.0411	.0383	.2319	.0167
Distance to nearest Interstate	.2388	.3335	-.0991	.7939	-.0546	-.0398	.0296
Overall quality of accessibility-then	.2737	.7354	-.0776	.3938	-.0132	.3758	-.0041
City water availability	.4618	-.0474	-.2300	.1449	.3410	-.1211	-.0809
Gas availability	.3970	.1632	-.0772	.6853	.2146	.0021	-.0782
City sewage availability	.7317	.1081	-.2707	.0559	.1039	.1287	-.0630
Did community have zoning then?	.7436	.2299	.1765	.2003	-.0742	-.1626	.1452
Was it zoned for industry?	.8335	.1382	.0511	.2711	.0455	-.0162	.1244
Was industry already in area?	.5867	.1488	.0333	.1699	.1395	.2804	-.1951
Was a building already there?	-.1042	.1399	-.5801	.0959	.0948	-.0838	.1895
Rating of land use compatibility	.0298	.0474	.3902	-.0099	-.0700	.4954	.2554
Nearby community services	-.4895	-.2574	.4806	.0193	-.2198	.0327	.1330
Was the site in an industrial park?	.6540	.0257	.5290	-.1044	-.0253	.0079	-.0599
Proxomity to Knoxville	.1682	.6957	-.1905	.1818	.0692	-.1110	-.0170
Amount of other industry located nearby	-.7324	-.2781	.0938	-.0883	-.1265	-.3664	.1475

VARIMAX ROTATED FACTOR MATRIX

TABLE 42

FACTOR IV

DISTANCE TO MAJOR HIGHWAY
DISTANCE TO NEAREST INTERSTATE
GAS AVAILABILITY

FACTOR V

SLOPE OF LAND
(CLEARING-COVER CONDITIONS)

FACTOR VI

DISTANCE TO RAILWAY
(LAND USE COMPATIBILITY)

FACTOR VII

(DISTANCE TO NEAREST MAJOR THOROUGHFARE)

Several observations regarding the results of the factor analysis should be noted. Firstly, the variables did not group as previously conceived in Chapter II. This suggests that an alternate grouping of variables to form indexes should be considered. This is not particularly disturbing since the original grouping was based upon a literature search of and not upon quantitative analysis.

Secondly, the first three factors account for nearly half of the original variance in the data (Table 40). These factors, therefore, may be sufficient to capture the industrial land conversion process provide appropriate weights can be found to reflect varying locational preferences of specific industries. This would reduce the number of variables to be measured to approximately 13.

Thirdly, a designated or zoned place for industry with some industry already nearby, appears to be the most important consideration in the site selection process. This is statistically verified only for the 16-county metropolitan region but such an observation is not inconsistent with empirical studies noted in Chapter II.

Finally, the remaining factors, although identified as statistically distinct, have a degree of communality in that each relates to some aspect of accessibility to the site. This suggests that a combined index of accessibility should be considered.

Further comments and recommendations concerning the development of a site selection algorithm are found in the final chapter.

CHAPTER V

SUMMARY AND CONCLUSIONS

Summary

The objectives of this research effort represent only a portion of a much larger research goal, the identification of the determinants affecting land use change. It was decided to focus upon only one aspect of this problem, the conversion of land to industrial use. The approach was based upon the assumption that the determinants of this conversion process would be found in the "market place," where land transactions among buyers and sellers occur. This research directed toward only one side of the market transaction process, namely that of the purchaser's desires (in this case, the industrial developer) in securing an ideal or suitable site. The problem was to identify the ideal qualities, quantities or attributes desired in an industrial site and to formulate a general algorithmic statement to identify potential industrial sites.

Research procedures involved the developing of a list of variables previously noted to be related to industrial site selection and streamlining the list to a set suitable for statistical testing. Once the list was formulated, measurements were obtained for a sample of industries locating (or relocating) in the 16-county Knoxville metropolitan region in the period from 1950 to present. These data were then subjected to factor analysis to determine the interrelations of variables, to minimize the list of variables needed to describe the industrial site-selection process, and to determine if the preconceived ideas concerning the factors affecting the process were valid. Seven factors accounting for 72 percent of the variance found in the original data were identified. The results suggest that a planned, designated place for industry to locate and accessibility to the site are the two most important considerations in industrial site-selection decisions.

Conclusions

In general the objectives of this research effort have been accomplished. Although it would be desirable to conclude with a specific mathematical statement describing the industrial site selection process, it is simply not possible without the refinement of the analysis procedures to include more specific measures of variables and the inclusion of additional data. The following conclusions, however, have been determined.

Conclusions Regarding the Form of the Site-Selection Algorithm

The 27 variables did not group as previously conceived but nevertheless the factors present a logical arrangement of variables. Factors II, IV, VI, and VII are almost singularly identified by accessibility. Reexamination of the accessibility factors indicates they could be combined, thereby reducing the number of indexes to two or three. Apparently, each accessibility variable possesses distinct qualities not common with others. However, this does not mean they could not be combined into a single index. To compensate for the greater importance of specific accessibility variables, weights might be used in building siting potential scores. When this combination is effected, four indexes are identified: (1) a protected or planned area for industrial development; (2) space for industry to develop; (3) accessibility to transportation media; and (4) site preparation costs.

Conclusions Regarding the Proper Form of Model Operation

As suggested previously, additional research would produce a more complete algorithm to simulate the industrial site-selection process. The factors identified in this study, however, should form major components of the algorithm. There is some question as to whether it is possible to develop a completely deterministic algorithm. It is doubtful that we will ever be able to predict the exact location of industrial development; therefore, the selection of suitable industrial sites ultimately should be accomplished through stochastic procedures. It is likely that other types of land use development will have to be simulated in a similar manner. The algorithm form suggested in Chapter I which utilizes an aggregation of indexes lends itself to stochastic simulation. This study demonstrates a way in which parameters relevant to the location process can be determined and thus incorporated into the algorithm.

Conclusions Regarding the Use of Aerial Photography in Model Design

An ancillary objective of this analysis was that of demonstrating the utility of aerial photography in compiling land use data and determining measurements on relevant variables. A major initial problem in analyzing industrial sites is finding the site and locating them relative to specific grid coordinates. Aerial photography was found to be most useful for locating industries and, consequently, reduces field work time considerably.

The imagery utilized in this study was provided by NASA-Marshall Space Flight Center in Huntsville, Alabama. It was flown at a scale of 1:24,000. This permitted superimposition directly onto 1:24,000 TVA maps and greatly simplifying locational analysis procedures. The determination of neighborhood quality characteristics, slope characteristics, accessibility characteristics, and size of the site was also facilitated by air photo interpretation. In fact most of the variables identified by the factor analysis procedures may be determined and measured from aerial photography.

It should be stressed that the use of aerial photography was not a panacean solution to data acquisition problems. Field work and ground-truth surveys are always necessary. Analyses of this type, however, can benefit greatly from the use of aerial photography.

Conclusions Regarding Recommendations for Future Research

The data collection procedures and analysis procedures utilized in this research task have been proven to be useful in attempting to understand the industrial land conversion process. There is no reason that similar procedures might not be applied toward analyzing other types of land use conversion processes.

One might also consider variations of the factor analysis procedures to group industries having similar locational preferences rather than variables. Insight acquired in this study suggests that the locational criteria are regionally dependent such that differing location parameters may become important in other metropolitan regions. The procedures utilized in this study lend themselves to this type of analysis. The final conclusion is emphasized: the procedures developed and utilized in this research have a variety of potential applications to location analysis problems and permit one to calibrate and validate land use modeling algorithms.

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APPENDIX A

SAMPLE SURVEY FORM

SAMPLE SURVEY FORM

Latitude__________________ Longitude__________________

Industry Name____

ORNL Industry No.______________ Date of Entry__________________

SIC No.____________________________ Quadrangle__________________

County____________________________ Employment Beginning______

City____________________________ Employment Now___________

1, 2, 3, 4, 5, 6, 7, 8, 9, 10 Slope of land

1, 2, 3, 4, 5, 6, 7, 8, 9, 10 Drainage

1, 2, 3, 4, 5, 6, 7, 8, 9, 10 Clearing-cover conditions

1, 2, 3, 4, 5, 6, 7, 8, 9, 10 Distance to center of town

1, 2, 3, 4, 5, 6, 7, 8, 9, 10 Distance to nearest major throughfare

1, 2, 3, 4, 5, 6, 7, 8, 9, 10 Density of land use in immediate vicinity

1, 2, 3, 4, 5, 6, 7, 8, 9, 10 Rating of price of land

1, 2, 3, 4, 5, 6, 7, 8, 9, 10 Percent of urban area within 2-1/2 miles

1, 2, 3, 4, 5, 6, 7, 8, 9, 10 Distance to major highway

1, 2, 3, 4, 5, 6, 7, 8, 9, 10 Distance to secondary road

1, 2, 3, 4, 5, 6, 7, 8, 9, 10 Distance to railway

1, 2, 3, 4, 5, 6, 7, 8, 9, 10 Distance to airport

1, 2, 3, 4, 5, 6, 7, 8, 9, 10 Distance to waterway

1, 2, 3, 4, 5, 6, 7, 8, 9, 10 Distance to nearest Interstate

1, 2, 3, 4, 5, 6, 7, 8, 9, 10 Overall quality of accessibility (then)

1, 2, 3, 4, 5, 6, 7, 8, 9, 10 Overall quality of accessibility (now)

1, 2, 3, 4, 5, 6, 7, 8, 9, 10 City water availability

1, 2, 3, 4, 5, 6, 7, 8, 9, 10 Gas availability

1, 2, 3, 4, 5, 6, 7, 8, 9, 10 City sewage availability

1, 2, 3, 4, 5, 6, 7, 8, 9, 10 Was it zoned for industry?

1, 2, 3, 4, 5, 6, 7, 8, 9, 10 Was industry already in area?

1, 2, 3, 4, 5, 6, 7, 8, 9, 10 Overall rating of contiguous land use

1, 2, 3, 4, 5, 6, 7, 8, 9, 10 Condition of neighborhood

1, 2, 3, 4, 5, 6, 7, 8, 9, 10 Nearby community services

1, 2, 3, 4, 5, 6, 7, 8, 9, 10 Was the site in an industrial park?

1, 2, 3, 4, 5, 6, 7, 8, 9, 10 What was the quality of the site?

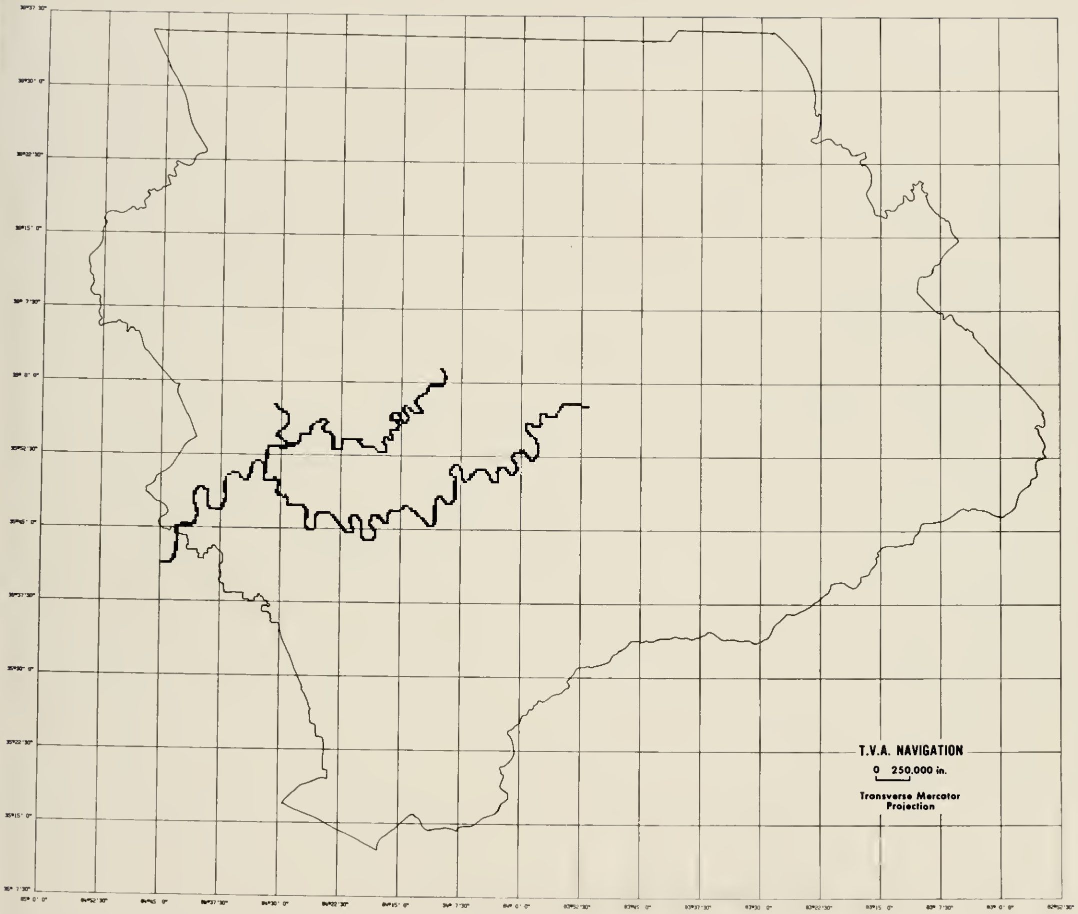
1, 2, 3, 4, 5, 6, 7, 8, 9, 10 Proximity to Knoxville

1, 2, 3, 4, 5, 6, 7, 8, 9, 10 Amount of other industry located nearby

1, 2, 3, 4, 5, 6, 7, 8, 9, 10 Was a building already there?

APPENDIX B

MAP OVERLAYS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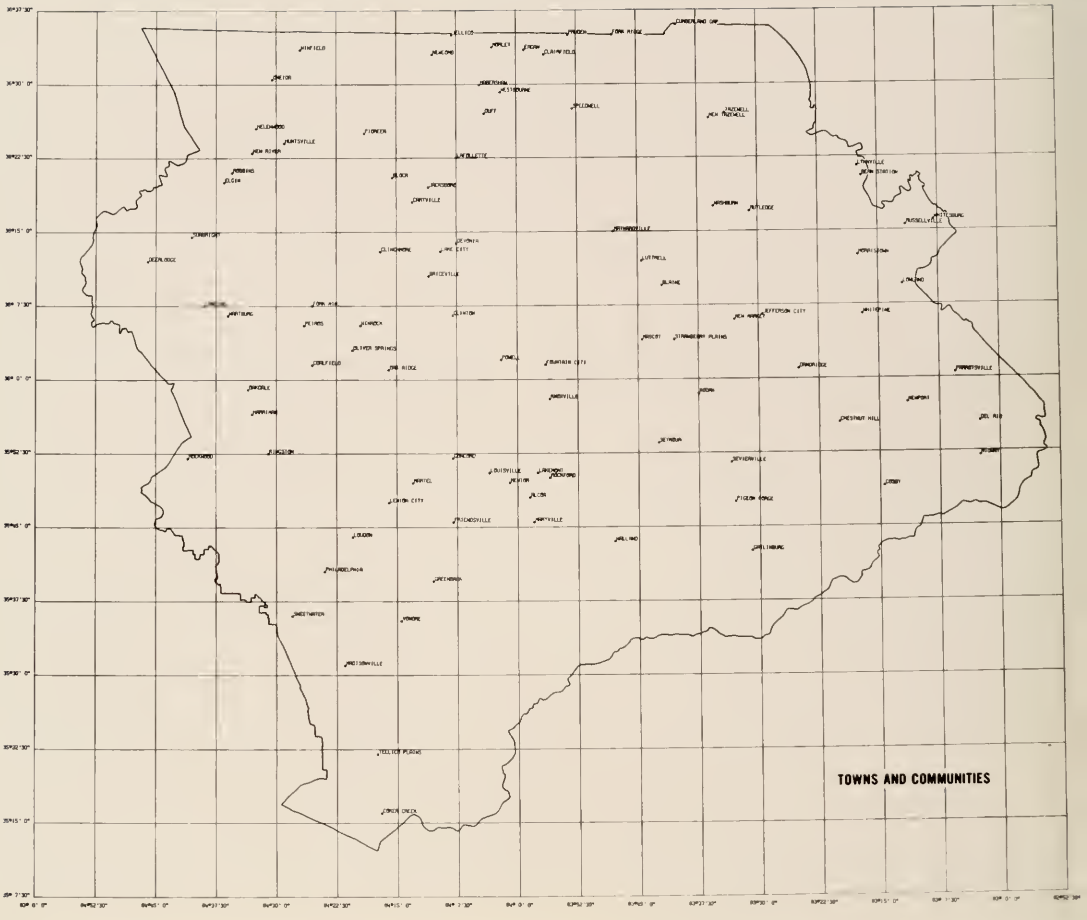
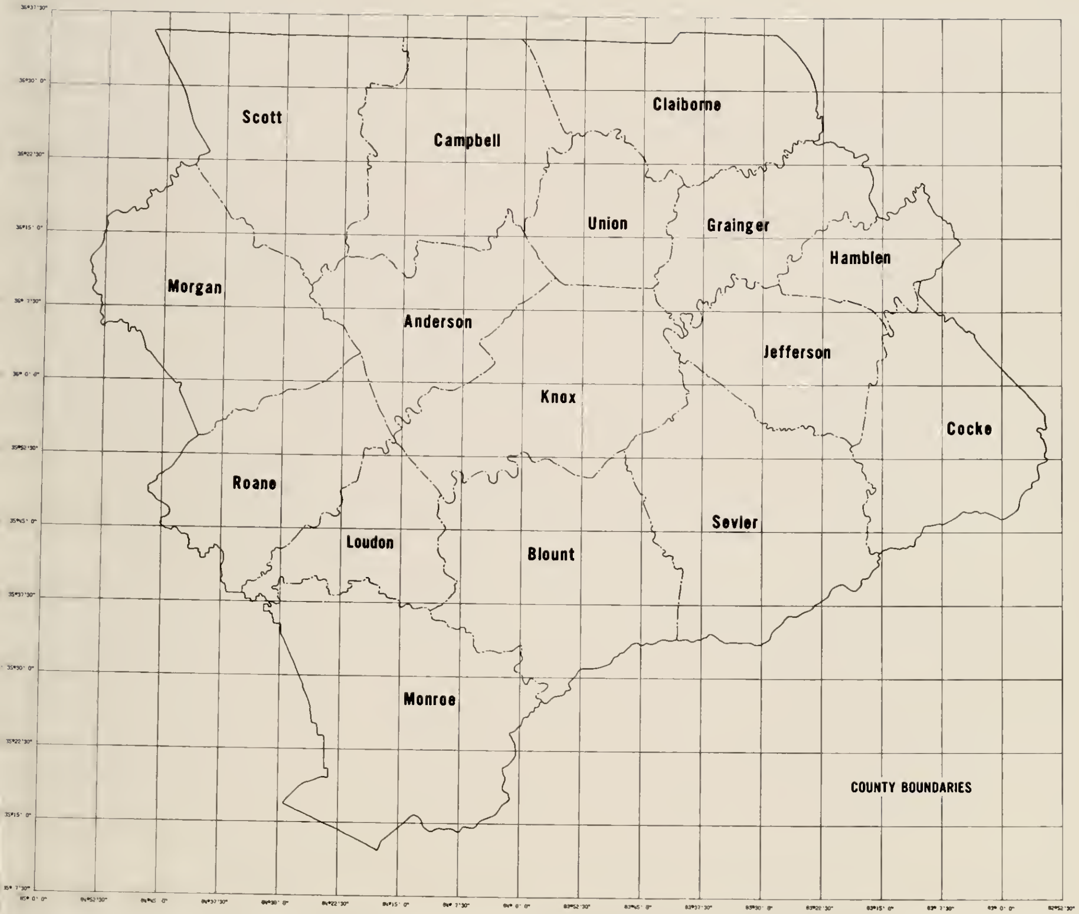
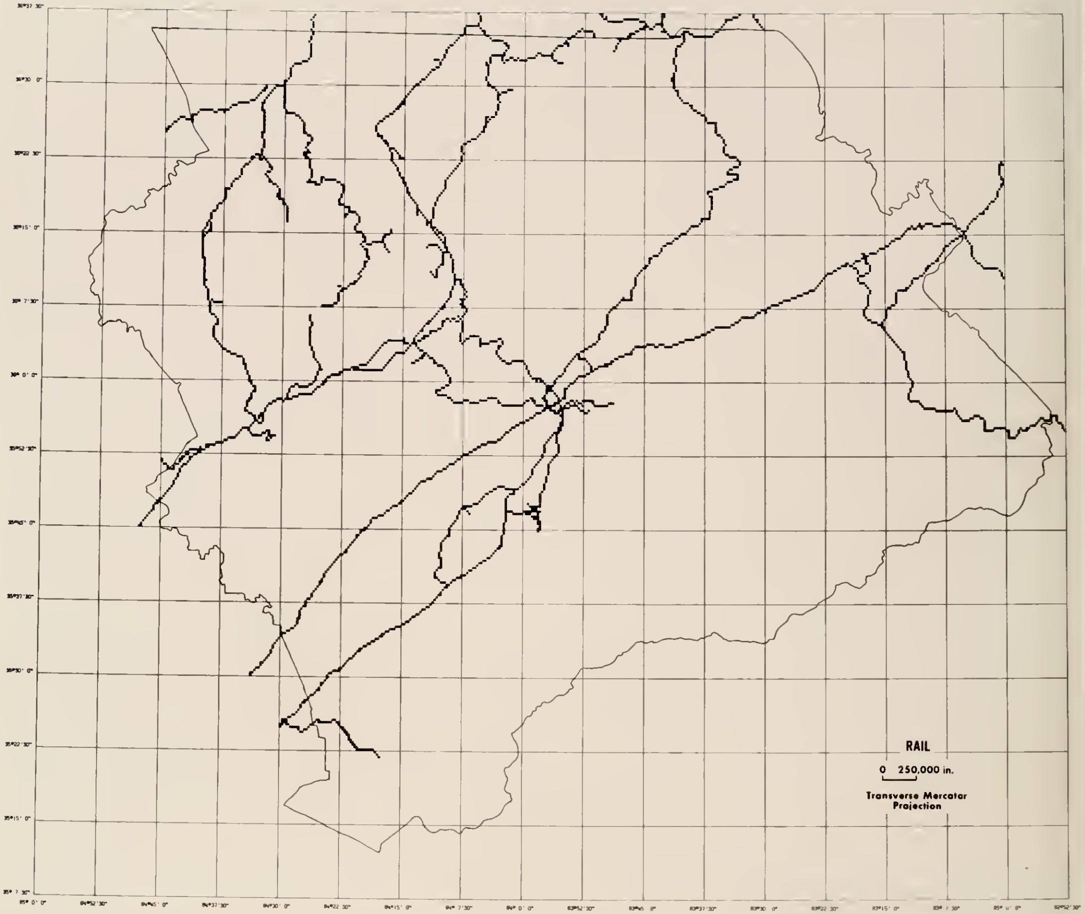


TOWNS AND COMMUNITIES



COUNTY BOUNDARIES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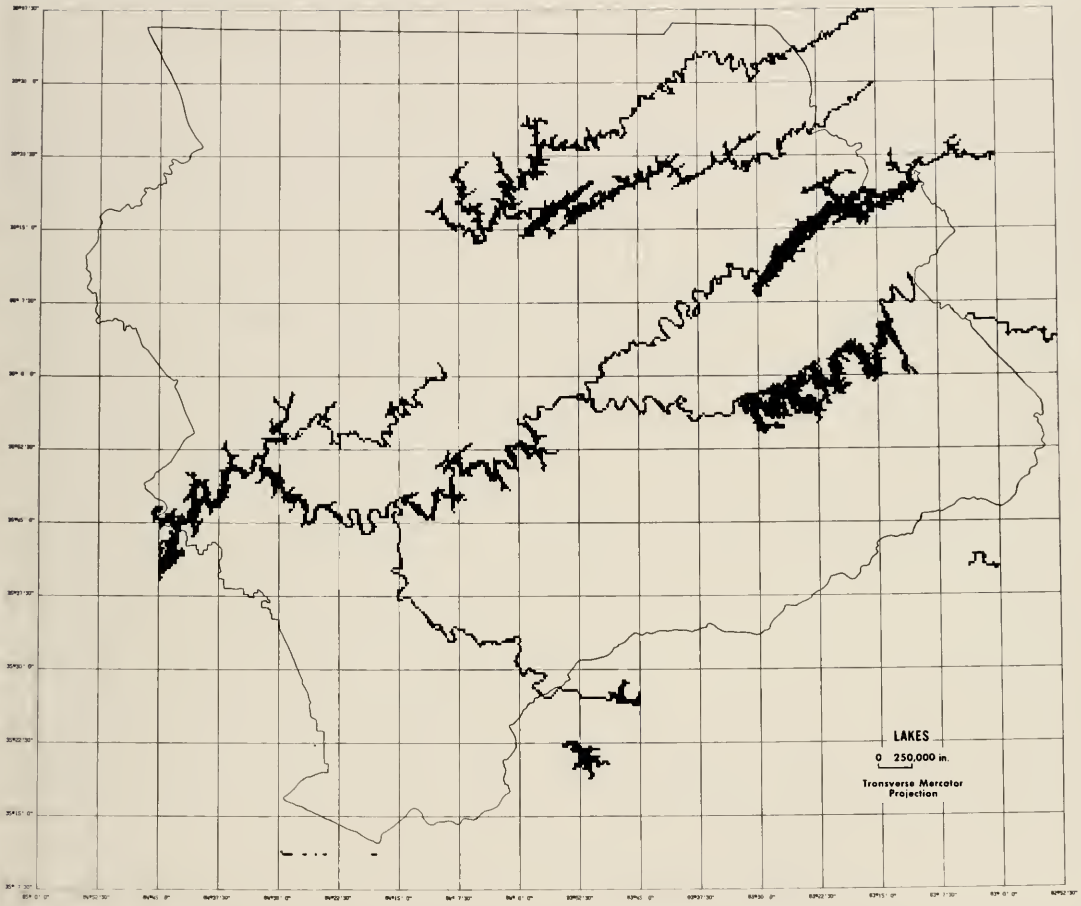
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BIOGRAPHICAL SKETCH

Robert Ben Honea was born in Athens, Georgia, on August 23, 1941. He received both his elementary and secondary education in Athens. He entered Georgia Military College located at Milledgeville, Georgia, in September, 1959. In September, 1960, he transferred to the University of Georgia, where he received the Bachelor of Science degree in Mathematics in 1964. In September, 1964, he entered the Graduate School of the University of Georgia in the Department of Geography. The degree Master of Arts was awarded to him in August, 1966. Between September, 1966, and March, 1972, he taught in the Department of Geography at East Tennessee State University, Johnson City, Tennessee. In March, 1972, he entered the Graduate School of the University of Florida to pursue graduate study toward the degree Doctor of Philosophy. In September, 1973, he returned to East Tennessee State University to teach while continuing his graduate study part-time. In July, 1974, he accepted a position as Research Associate in the Department of Regional and Urban Studies at Oak Ridge National Laboratory where he is presently employed. During his academic career he has been a research associate for the National Aeronautics and Space Administration, the U.S. Geological Survey, and the National Science Foundation. He is married and he and his wife have three children.

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

Clark I. Cross

Clark I. Cross, Chairman
Associate Professor of Geography

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

James R. Anderson by

James R. Anderson
Professor of Geography

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

Gary S. Shannon
Associate Professor of Geography

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

David L. Niddrie

David L. Niddrie
Professor of Geography

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

Clayton C. Curtis
Associate Professor of Real Estate

This dissertation was submitted to the Department of Geography in the College of Arts and Sciences and to the Graduate Council, and was accepted as partial fulfillment of the requirements for the degree of Doctor of Philosophy.

Dean, Graduate School

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